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CONTENTS

Miocene Foraminifera from Los Sauces Creek, Ventura County, California — *Joseph A. Cushman and Boris Laiming* 79

The Genus *Fagesia* in the Upper Cretaceous of the Pacific Coast — *Frank M. Anderson* 121

Lepidechinoides Olsson, a Genus of Devonian Echinoids — *Gustav A. Cooper* 127

Conodonts from the Arkansas Novaculite, Woodford Formation, Ohio Shale, and Sunbury Shale — *C. L. Cooper* 143

PALEONTOLOGICAL NOTES

A New Lower Cretaceous Ophiuroid — *C. I. Alexander* 152
A New Species of *Ampyx* — *Charles E. Decker* 153
Orientation of the Carapaces of Paleozoic Ostracoda — *Egmont Kummerow* 155
Notes on Ostracoda — *Charles H. Blake* 160
New Names for Species of *Bairdia* — *Bruce Harlton* 163

SOCIETY RECORDS AND ACTIVITIES

Fifth Annual Meeting of the Society of Economic Paleontologists and Mineralogists 164
Memorial—James Perrin Smith — *F. B. Plummer* 168

REVIEWS AND NEW PUBLICATIONS 171

AMONG PALEONTOLOGISTS 174

JOURNAL of PALEONTOLOGY

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MIOCENE FORAMINIFERA FROM LOS SAUCES CREEK, VENTURA COUNTY, CALIFORNIA

JOSEPH A. CUSHMAN and BORIS LAIMING
Sharon, Mass., Los Angeles, Calif.

ABSTRACT

The writers describe and figure 68 species of foraminifera from the so-called "Temblor clay shale" which overlies the oil-bearing Vaqueros sandstone in the Santa Barbara coastal region of California. The foraminifera were obtained from a series of 66 samples collected at rather regular intervals throughout the 2,000 feet of "clay shale" continuously exposed in a southern dipping monocline along Los Sauces Creek, south of Casitas Pass, in Ventura County, California.

The distribution and range of the species of foraminifera in this section are shown in a check list. The faunal zones are indicated not only on a check list, but also on a structure section, a columnar section, and a map of the area. Comparisons are made, furthermore, between the zonal assumblages represented in this section and those found in Temblor and Vaqueros strata of several other localities in the central Coast Ranges and the San Joaquin Valley.

The purpose of the writers is to describe a foraminiferal fauna from a "clay shale" series of Miocene age overlying the Vaqueros (Lower Miocene) sandstone, which is the principal oil-producing horizon of the Santa Barbara region, California. This shale series comprises about 2,300 feet of strata exposed in continuous outcrop along the bed of Los Sauces Creek, at the foot of the eastern slope of Rincon Mountain, Ventura County, California. Sixty-six foraminiferal samples were collected from this shale series, and located by planetable traverse. The section was measured from the base of the exposed foraminiferal shale up to the base of a siliceous shale which contains foraminifera of Monterey (Middle Miocene) age.

The foraminiferal strata described in this paper represent the middle portion of a conformable succession of sandstone, clay shale, and siliceous shale of Miocene age, which rests upon the red sandstone beds of the Sespe (Oligocene ?) formation exposed at the head of Los Sauces Creek, along Casitas Pass. The Miocene sediments have a thickness of about 3,400 feet, and form the north flank of a sharply folded syncline, the axis of which cuts across Los Sauces Creek in an east-west direction, at a

point 660 feet S. 88° W. from the east quarter corner of Sec. 5, T. 3 N., R. 24 W., San Bernardino base and meridian.

The Vaqueros sandstone beds form conspicuous strike ridges across Los Sauces Creek, and have a total thickness of about 400 feet. Megascopic fossils were found by the junior writer in the stratigraphically highest bed of hard greenish-gray calcareous sandstone (Locality 85),

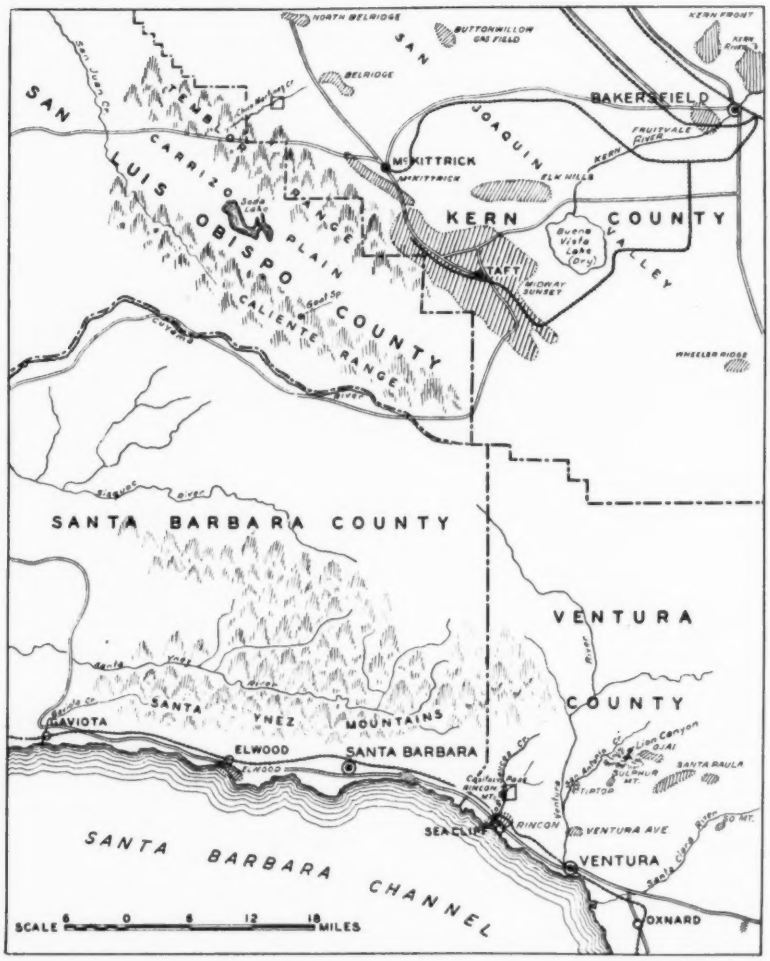


FIG. 1.—Sketch map showing location of Los Sauces Creek section near coast about midway between Ventura and Santa Barbara, California.

1,200 feet N. 44° W. from locality 1-A, and also along the slope of the ridge in boulders of similar material. The species found are the following:

Fossils from upper part of Vaqueros sandstone, Los Sauces Creek.

Pecten sespeensis var. hydei Arnold.
Mytilus aff. mathewsonii Gabb, var. expansus Arnold.
Balanus aff. concavus Bronn.
Ostrea sp.

These forms are listed by Eldridge and Arnold[1] from the Vaqueros formation exposed at the east end of Ojai Valley and in Little Sespe Creek, Ventura County, California.

According to R. M. Kleinpell,[2] the sandstone beds in Los Sauces Creek can be traced into those exposed in San Antonio Creek, near the mouth of Lion Canyon, Ventura Quadrangle, California, except where they are occasionally covered by stream fill. These beds in San Antonio Creek contain *Pecten magnolia* Conrad, *Turritella* aff. *inezana* Conrad, and other Vaqueros fossils.

The foraminiferal "clay shale" series overlying the Vaqueros sandstone beds in Los Sauces Creek is divided lithologically and microfaunally into lower, middle, and upper members.

LOWER "CLAY SHALE" MEMBER

The Lower Member consists of 700 feet of greenish-buff, massive mudrock, weathering gray, containing occasional lenses of hard gray sandstone, and becoming sandy toward the base. The lower part of this member, exposed to the west of the creek, contains only unidentified limonitic casts of foraminifera. Its upper part is represented by sample localities 1-A to 15, and is rich in foraminifera.

The microfauna of the Lower Member is quite distinctive and consists of 48 species of calcareous and arenaceous foraminifera listed in Table 1. Of the 48 species, 28 disappear at the contact with the succeeding Middle Member, and are not found higher in this section. Of these 28 species, 10 are not recorded from any younger formations in southern California. The following lists give the names of these 10 species (group A), of other characteristic and common species of the Lower Member (group B), and species that are abundant in this member but range higher in the section (group C).

[1]G. H. Eldridge and Ralph Arnold, "The Santa Clara Valley Puente Hills and Los Angeles Oil Districts, Southern California," U. S. Geol. Survey Bull. 309 (1907), pp. 12-14.

[2]R. M. Kleinpell, Geologist, Los Angeles, California, oral communication.

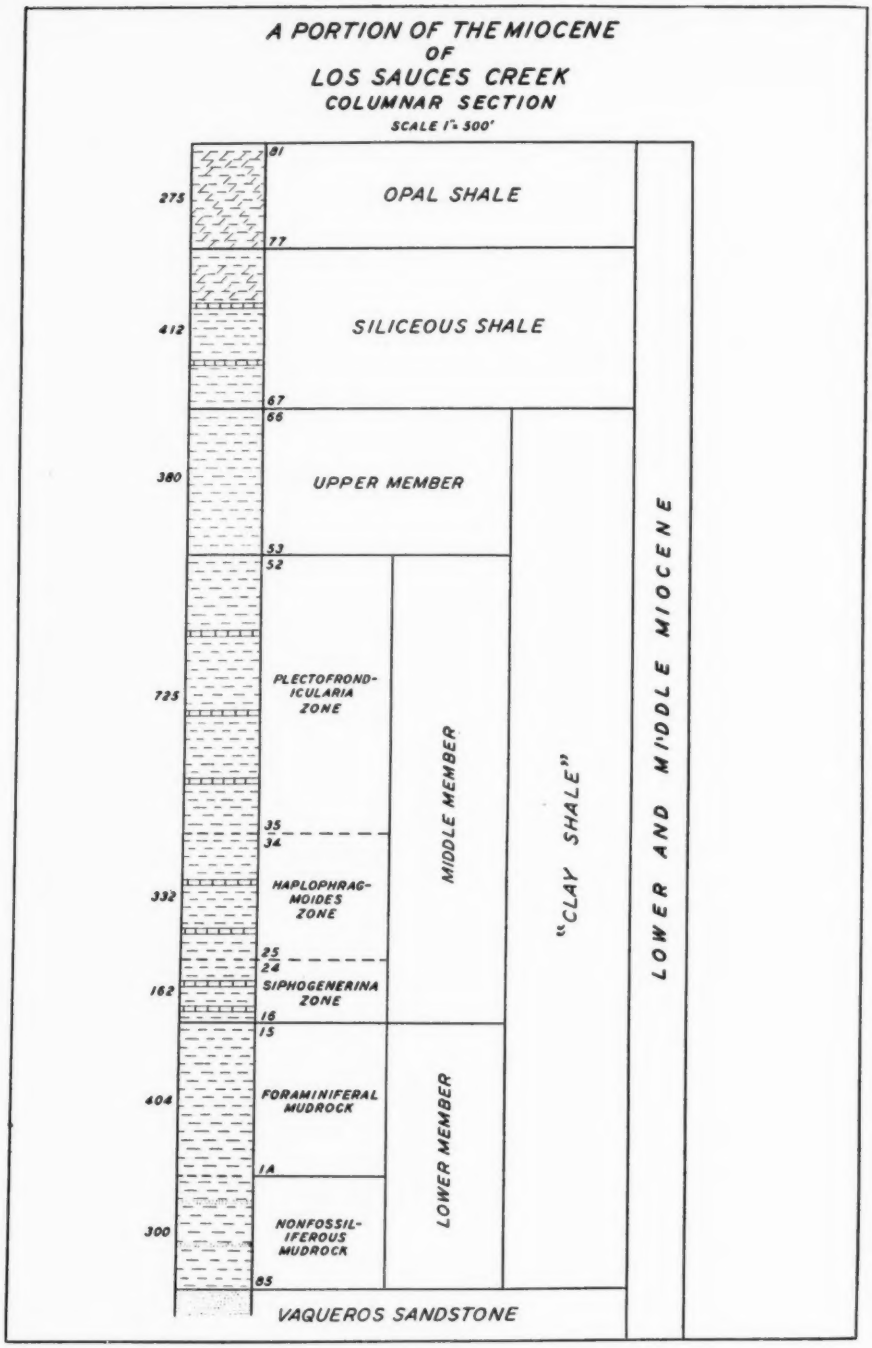

A PORTION OF THE MIOCENE
OF
LOS SAUCES CREEK
COLUMNAR SECTION
SCALE 1"= 300'
275
412
380
725
332
162
404
300
81
77
67
66
53
52
35
34
25
24
16
15
1A
85
OPAL SHALE
SILICEOUS SHALE
UPPER MEMBER
PLECTOFROND-
ICULARIA
ZONE
HAPLOPHRAG-
MOIDES
ZONE
SIPHOGENERINA
ZONE
FORAMINIFERAL
MUDROCK
NONFOSSIL-
IFEROUS
MUDROCK
MIDDLE MEMBER
LOWER MEMBER
"CLAY SHALE"
VAQUEROS SANDSTONE
LOWER AND MIDDLE MIOCENE

FIG. 2

Foraminifera of the Lower Member of the Los Sauces Creek Miocene clay shale

GROUP A
- Anomalina glabrata Cushman
- Bulimina rinconensis Cushman and Laiming, n. sp.
- Eponides affinis (Czjzek)
- Guttulina hughesi Cushman and Laiming, n. sp.
- Marginulina dubia Neugeboren
- Sigmomorphina reedi Cushman and Laiming, n. sp.
- Siphogenerina sp.
- Spiroplectammina gracilis (von Marck)
- Trochammina parva Cushman and Laiming, n. sp.
- Uvigerinella sparsicostata Cushman and Laiming, n. sp.

GROUP B
- Angulogerina occidentalis Cushman
- Cancris sagra (d'Orbigny)
- Cibicides americanus (Cushman)
- Gaudryina gracilis Cushman and Laiming, n. sp.
- Glandulina laevigata d'Orbigny
- Globobulimina pacifica Cushman
- Nonion incisa (Cushman)
- Pullenia salisburyi R. E. and K. C. Stewart
- Robulus nicobarensis (Schwager)
- Virgulina bramlettei Galloway and Morrey
- Virgulina floridana Cushman

GROUP C
- Buliminella curta Cushman
- Cyclammina cancellata H. B. Brady, var. obesa Cushman and Laiming, n. var.
- Cyclammina incisa (Stache)
- Gaudryina triangularis Cushman
- Gyroidina soldanii d'Orbigny
- Haplophragmoides trullissata (H. B. Brady)
- Valvulineria casitasensis Cushman and Laiming, n. sp.

Foraminifera identical with the species just listed from the Lower Member of Los Sauces Creek section are found in strata overlying the Vaqueros "reef beds" throughout the Santa Barbara coastal region of California. The following species are listed by the junior writer from the lower 350 feet of a section measured near the mouth of Gaviota Creek, Lompoc Quadrangle, California, about 40 miles west of Los Sauces Creek, immediately overlying the Vaqueros "reef beds:"

Foraminifera from beds above the Vaqueros, on Gaviota Creek

- Angulogerina occidentalis (Cushman)
- Anomalina glabrata Cushman
- Bolivina aff. marginata Cushman
- Bulimina rinconensis Cushman and Laiming, n. sp.
- Cancris sagra (d'Orbigny)
- Cassidulina aff. pulchella d'Orbigny
- Cibicides americanus (Cushman)
- Cibicides floridanus (Cushman)
- Cyclammina incisa (Stache)
- Ellipsolagena sp.
- Eponides affinis (Czjzek)
- Gaudryina triangularis Cushman
- Glandulina laevigata d'Orbigny
- Globigerina bulloides d'Orbigny
- Globigerina conglomerata Schwager
- Globobulimina pacifica Cushman
- Guttulina hughesi Cushman and Laiming, n. sp.
- Gyroidina soldanii d'Orbigny
- Haplophragmoides trullissata (H. B. Brady)
- Lagena sulcata (Walker and Jacob) var. apiculata Cushman
- Marginulina dubia Neugeboren
- Marginulina sp.
- Nonion incisa (Cushman)
- Pullenia salisburyi R. E. and K. C. Stewart
- Robulus simplex (d'Orbigny)
- Sigmomorphina reedi Cushman and Laiming, n. sp.
- Sphaeroidina bulloides d'Orbigny
- Spiroplectammina gracilis (von Marck)
- Uvigerinella sparsicostata Cushman and Laiming, n. sp.
- Valvulineria casitasensis Cushman and Laiming, n. sp.

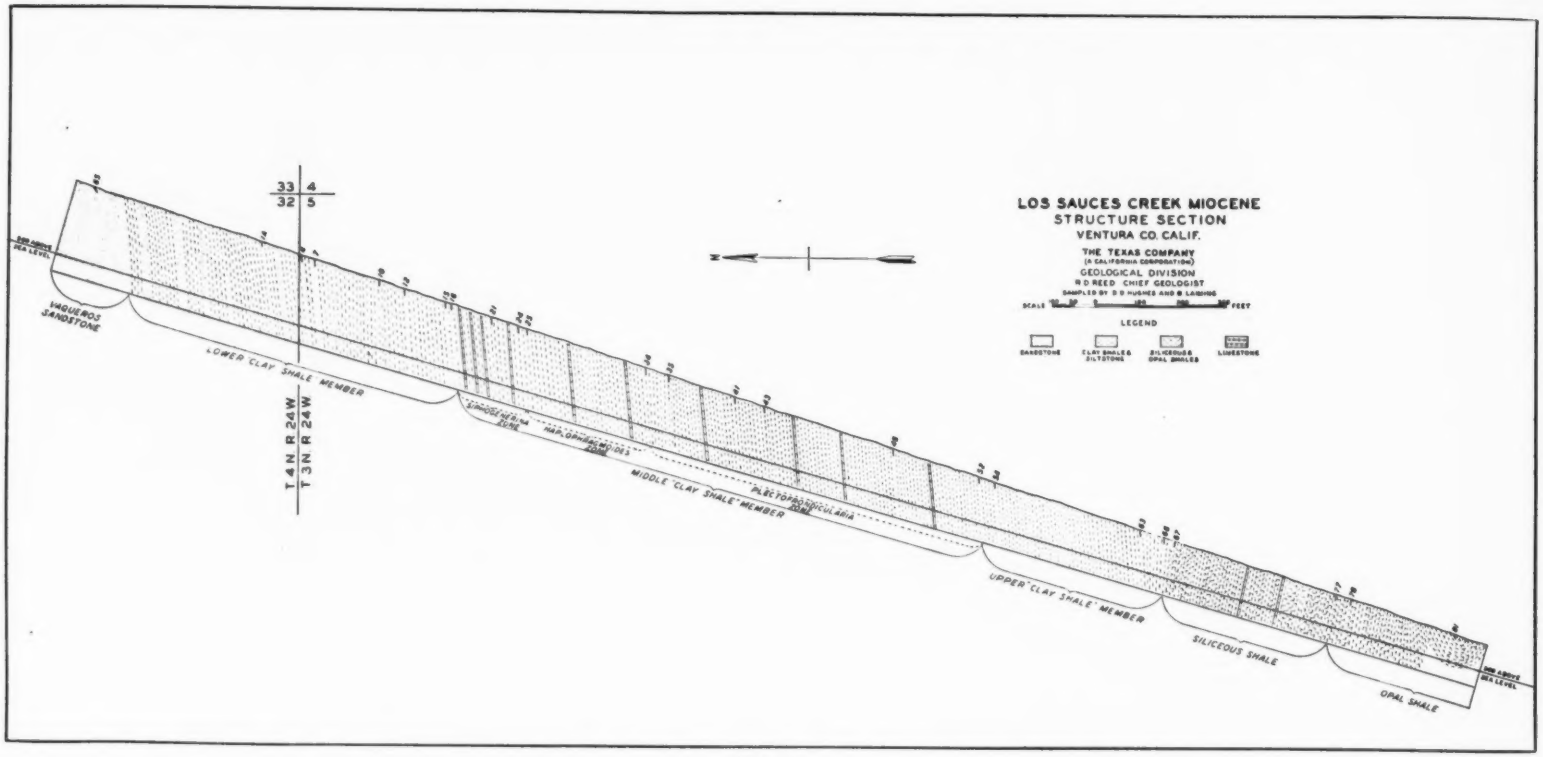

LOS SAUCES CREEK MIOCENE
STRUCTURE SECTION
VENTURA CO. CALIF.
THE TEXAS COMPANY
(A CALIFORNIA CORPORATION)
GEOLOGICAL DIVISION
R D REED CHIEF GEOLOGIST
SAMPLED BY D D HUENEKE AND B LANDING
SCALE
FEET
LEGEND
SANDSTONE
CLAY SHALES SILTSTONES
SILICEOUS & OPAL SHALES
LIMESTONE
33
32
4
5
T 4 N R 24 W
T 3 N R 24 W
VAQUEROS SANDSTONE
LOWER CLAY SHALE MEMBER
SPHAEROIDINA ZONE
MIDDLE CLAY SHALE MEMBER
PLECTOFROSTICULARIA ZONE
UPPER CLAY SHALE MEMBER
SILICEOUS SHALE
OPAL SHALE

FIG. 3

This fauna is well known from the lower 300 feet of so-called Temblor clay shale overlying the Vaqueros oil-producing horizon in Elwood and in other fields along the Santa Barbara coast, where it has been cored.

A foraminiferal assemblage of several species, identical with those in the Lower Member of the Los Sauces Creek section, is present in a sample from a depth of 5,543 feet in the General Petroleum Corporation's well Kerwin No. 1, in Sec. 5, T. 30 S., R. 29 E., Mount Diablo base and meridian, Edison District, California, where it occurs along with *Turritella inezana* Conrad. The following species of foraminifera are listed in this sample.

Foraminifera from sample at 5,543 feet in General Petroleum Corporation's Kerwin No. 1

Cassidulina aff. pulchella d'Orbigny
Cibicides floridanus (Cushman)
Gaudryina triangularis Cushman
Gyroidina soldanii d'Orbigny
Nonion incisa (Cushman)
Uvigerinella aff. sparsicostata Cushman and Laiming, n. sp.

W. H. Corey,[1] who identified *Turritella inezana* Conrad in the sample from the Kerwin well, states that this species is confined principally to the Vaqueros formation, but in a few instances, has been recorded in the transition zone immediately overlying the true Vaqueros.

MIDDLE "CLAY SHALE" MEMBER

The Middle Member of the Los Sauces Creek section overlies the Lower Member with a gradational contact, and consists of dark brown to chocolate brown, conchoidally weathering, very compact mudrock. Hard limestone lenses and beds, from one to several feet in thickness, occur at rather regular intervals of approximately 30 feet in the basal part of this member. The limestone beds occur less frequently higher in the section, while large limestone concretions appear in increasing numbers. The Middle Member is represented by sample localities 16 to 52, and has a total thickness of 1,219 feet. Numerous small concretionary bodies, designated by E. W. Galliher[2] as collophane oölites, occur occasionally in the upper part of the Middle Member.

On the basis of foraminifera the Middle Member of the Los Sauces Creek section is divisible into three faunal zones: the lower, or *Siphogenerina transversa* zone; the middle, or *Haplophragmoides trullissata* zone; and the upper, or *Plectofrondicularia miocenica* zone. The species for

[1]W. H. Corey, Paleontologist, San Francisco, California, written communication.

[2]E. W. Galliher, "Collophane from the Miocene Brown Shales of California," paper read before the Pacific Section of Am. Assn. Petroleum Geol., Nov. 6, 1930, Los Angeles, California.

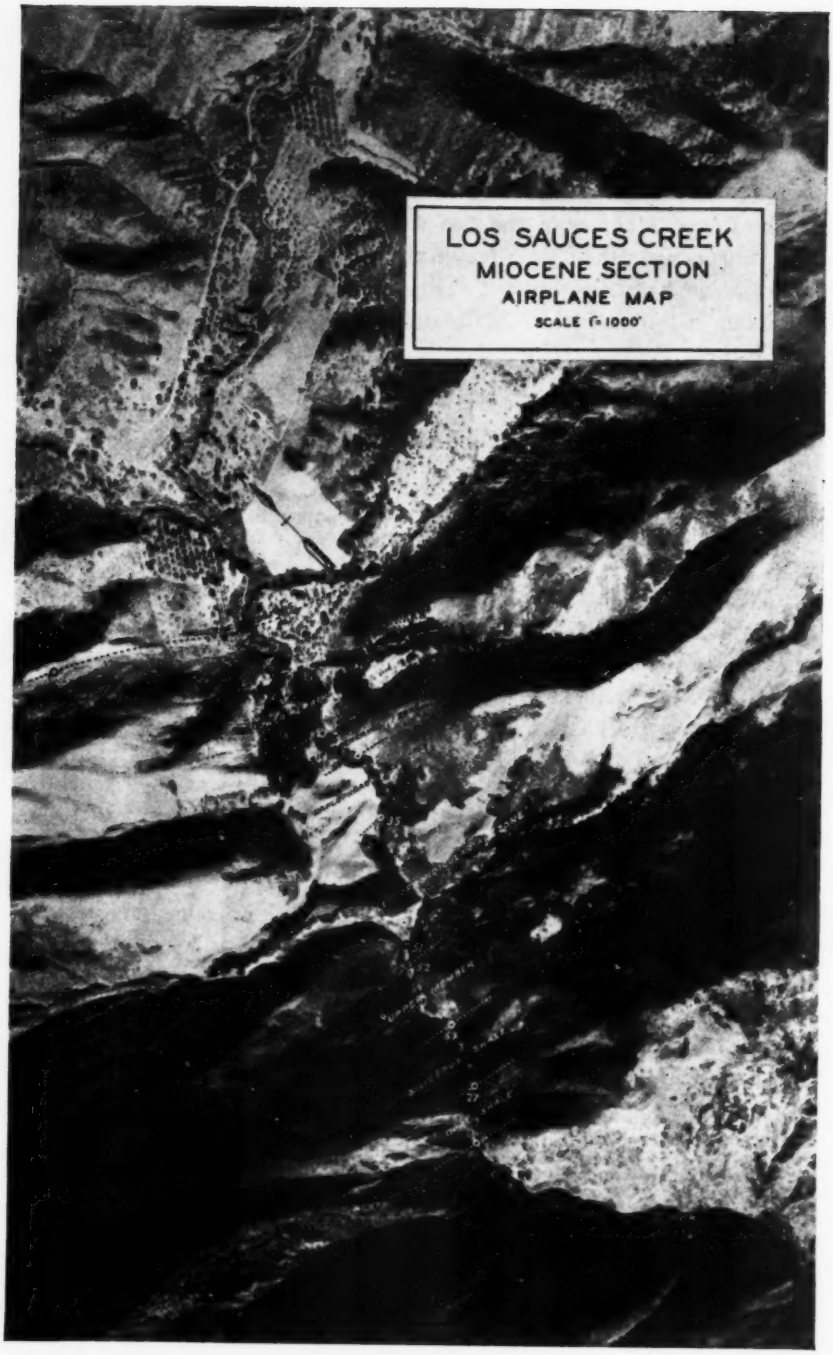


FIG. 4

which these zones are named are the dominant forms in the respective zones.

(1) The *Siphogenerina transversa* zone comprises 162 feet of strata at the base of the Middle Member. The assemblage of foraminifera in this zone is limited to a small number of species represented by numerous individuals. The characteristic forms are the following.

Characteristic foraminifera of the Siphogenerina transversa *zone*

Bolivina marginata Cushman (form figured on Pl. 4, figs. 7, 8)
Clavulina patens Cushman and Laiming, n. sp.
Eponides nanus (Reuss)
Plectofrondicularia sp.
Siphogenerina transversa Cushman
Valvulineria casitasensis Cushman and Laiming, n. sp.

The tests of nearly all the foraminifera in this zone appear to be altered or collapsed. This condition has been observed not only in Los Sauces Creek samples, but also in samples from a number of wells along the Santa Barbara coast which have penetrated equivalent beds, and from the Gaviota Creek section, Lompoc Quadrangle, California.

(2) The *Haplophragmoides trullissata* zone has a thickness of 332 feet in Los Sauces Creek, and contains only arenaceous foraminifera, most of which are found in a rather poor state of preservation. The foraminifera found in this zone are the following.

Foraminifera of the Haplophragmoides trullissata *zone*

Ammodiscus cf. incertus (d'Orbigny)
Clavulina patens Cushman and Laiming, n. sp.
Cyclammina cancellata H. B. Brady, var. obesa Cushman and Laiming, n. var.
Cyclammina incisa (Stache)
Gaudryina cf. flintii Cushman
Gaudryina gracilis Cushman and Laiming, n. sp.
Haplophragmoides trullissata (H. B. Brady)

(3) The *Plectofrondicularia miocenica* zone of the Middle Member of Los Sauces Creek section differs from the underlying zone in the presence of calcareous foraminifera along with most of the arenaceous forms listed in the zone below. The *Plectofrondicularia miocenica* zone includes sample localities 35 to 52, and has a thickness of 725 feet. The species of foraminifera constituting the characteristic assemblage for this zone are the following.

Foraminifera of the Plectofrondicularia miocenica *zone*

Bolivina marginata Cushman (form figured on Pl. 4, fig. 6)
Cyclammina cancellata H. B. Brady, var. obesa Cushman and Laiming, n. var.

Gyroidina soldanii d'Orbigny
Haplophragmoides trullissata (H. B. Brady)
Nonion costifera (Cushman)
Plectofrondicularia miocenica Cushman
Pulvinulinella parva Cushman and Laiming, n. sp.
Robulus simplex (d'Orbigny)
Uvigerinella obesa Cushman, var. impolita Cushman and Laiming, n. var.

A few other forms are occasionally present; among them *Siphogenerina transversa* Cushman, occurring at the base of the zone, is the most prominent. Collophane oölites, as already noted, occur at the top of the *Plectofrondicularia* zone. The occurrence of these in the Los Sauces Creek section is, however, much more restricted numerically than in the well sections along the Santa Barbara coast, where they have been found in great abundance in cores from equivalent strata.

The microfauna from the Middle Member of the Los Sauces Creek section has a close affinity for a fauna from the Temblor formation exposed in the Caliente Range, McKittrick Quadrangle, California. The following species, all of which are present in the Middle "Clay Shale" Member of Los Sauces Creek, are listed from the Caliente Range.

Foraminifera from the Temblor formation in the Caliente Range

Clavulina patens Cushman and Laiming, n. sp.
Cibicides floridanus (Cushman)
Gaudryina cf. flintii Cushman
Gaudryina triangularis Cushman
Haplophragmoides trullissata (H. B. Brady)
Nonion costifera (Cushman)
Robulus aff. simplex (d'Orbigny)
Uvigerinella obesa Cushman
Uvigerinella obesa Cushman, var. impolita Cushman and Laiming, n. var.

This fauna was collected by J. E. Eaton[1] at Goat Spring, in Secs. 32 and 33, T. 12 N., R. 27 W., San Bernardino base and meridian, 50 miles north of Los Sauces Creek, and loaned the writers by Paul P. Goudkoff.[2] According to Mr. Easton, his foraminiferal collection comes from approximately the center of a 4,000-foot succession of beds which carry the Temblor guide fossil *Turritella ocoyana* Conrad throughout, and form part of the most complete known Miocene section in California, some 12,000 feet thick, in Caliente Range.

UPPER "CLAY SHALE" MEMBER

The Upper Member of the Los Sauces Creek section overlies the *Plectofrondicularia miocenica* zone of the Middle Member with a grada-

[1]J. E. Eaton, Geologist, Los Angeles, California, personal communication.

[2]Paul P. Goudkoff, Geologist, Los Angeles, California.

tional contact. It consists of dark brown, massive, silty mudrock, locally iron stained, and containing occasional sandy and calcareous lenses. This member lies between sample localities 53 and 66, and has a thickness of 300 feet. The characteristic assemblage of foraminifera in it is distinct from that of the underlying faunal zone, although some of the species present in that zone are also found in this member. The disappearance of *Uvigerinella obesa* Cushman, var. *impolita* Cushman and Laiming, n. var., and of the genus *Cyclammina*, and the first appearance of *Uvigerinella obesa* Cushman mark the contact between the *Plectofrondicularia miocenica* zone and the Upper Member of the Los Sauces Creek section. The following species appear to be characteristic of the Upper Member of the section.

Characteristic foraminifera of the Upper "Clay Shale" Member of Los Sauces Creek

Bolivina advena Cushman, var. striatella Cushman
Bulimina inflata Seguenza, var. alligata Cushman and Laiming
Buliminella subfusiformis Cushman
Dentalina pauperata d'Orbigny
Dentalina quadrulata Cushman and Laiming
Nonion costifera (Cushman)
Plectofrondicularia miocenica Cushman, var. directa Cushman and Laiming, n. var.
Pulvinulinella subperuviana Cushman, var. minuta Cushman and Laiming, n. var.
Uvigerinella obesa Cushman
Uvigerinella californica Cushman, var. ornata Cushman

A similar assemblage of foraminifera is recognized in well cores from the Santa Barbara region, where it is contained in brown shales variously designated by field geologists as Temblor or lower Monterey in age.

The foraminiferal assemblage near the top of the Upper "Clay Shale" Member bears an affinity for a fauna occurring 500 feet below the top of the "button bed" which contains *Scutella merriami* Anderson, and is exposed in the north east quarter of Sec. 9, T. 29 S., R. 20 E., Mount Diablo base and meridian, along Chico Martinez Creek, McKittrick Quadrangle, California. The fauna from Chico Martinez Creek, collected by W. D. Kleinpell and loaned the junior writer by D. D. Hughes,[1] contains the following species, which are also commonly found in the Upper Member of the Los Sauces Creek section.

Foraminifera from below the "button bed" on Chico Martinez Creek

Bulimina inflata Seguenza, var. alligata Cushman and Laiming, n. var.
Buliminella subfusiformis Cushman
Buliminella curta Cushman
Cibicides floridanus (Cushman)

[1]D. D. Hughes, Paleontologist, Los Angeles, California.

Dentalina quadrulata Cushman and Laiming, n. sp.
Globigerina conglomerata Schwager
Nodogenerina advena Cushman and Laiming, n. sp.
Nonion costifera (Cushman)
Robulus aff. simplex (d'Orbigny)
Siphogenerina transversa Cushman
Uvigerinella californica Cushman, var. ornata Cushman

A hard gray siliceous shale overlies the Upper Member of the Los Sauces Creek section. This siliceous shale, about 400 feet thick, is interbedded with limestone and earthy brown siltstone containing foraminifera, and grades upward into hard, platy, light brown to whitish, opal shale, 275 feet of which are exposed in Los Sauces Creek north of the axis of the major Miocene syncline crossing the creek. The prevailing dips of 70° in Los Sauces Creek section increase rapidly to 87° in the basal beds of the siliceous shale, while the general strike of N. 70° W. remains unchanged.

A foraminiferal fauna collected near the base of the opal shale in Los Sauces Creek appears to be correlative with the fauna from the lower part of the type Monterey described by Hanna,[1] and listed as Number 1410 in the collection of the California Academy of Sciences. This fauna is included in the description of the foraminifera from the Monterey shale of California by Cushman.[2]

The writers are indebted to The Texas Company, Los Angeles, California, for permission to use the original samples, and for the preparation of the maps accompanying the paper. The junior writer is also much indebted to Messrs. Ralph D. Reed and Donald D. Hughes for their helpful suggestions and criticism during the preparation of this paper.

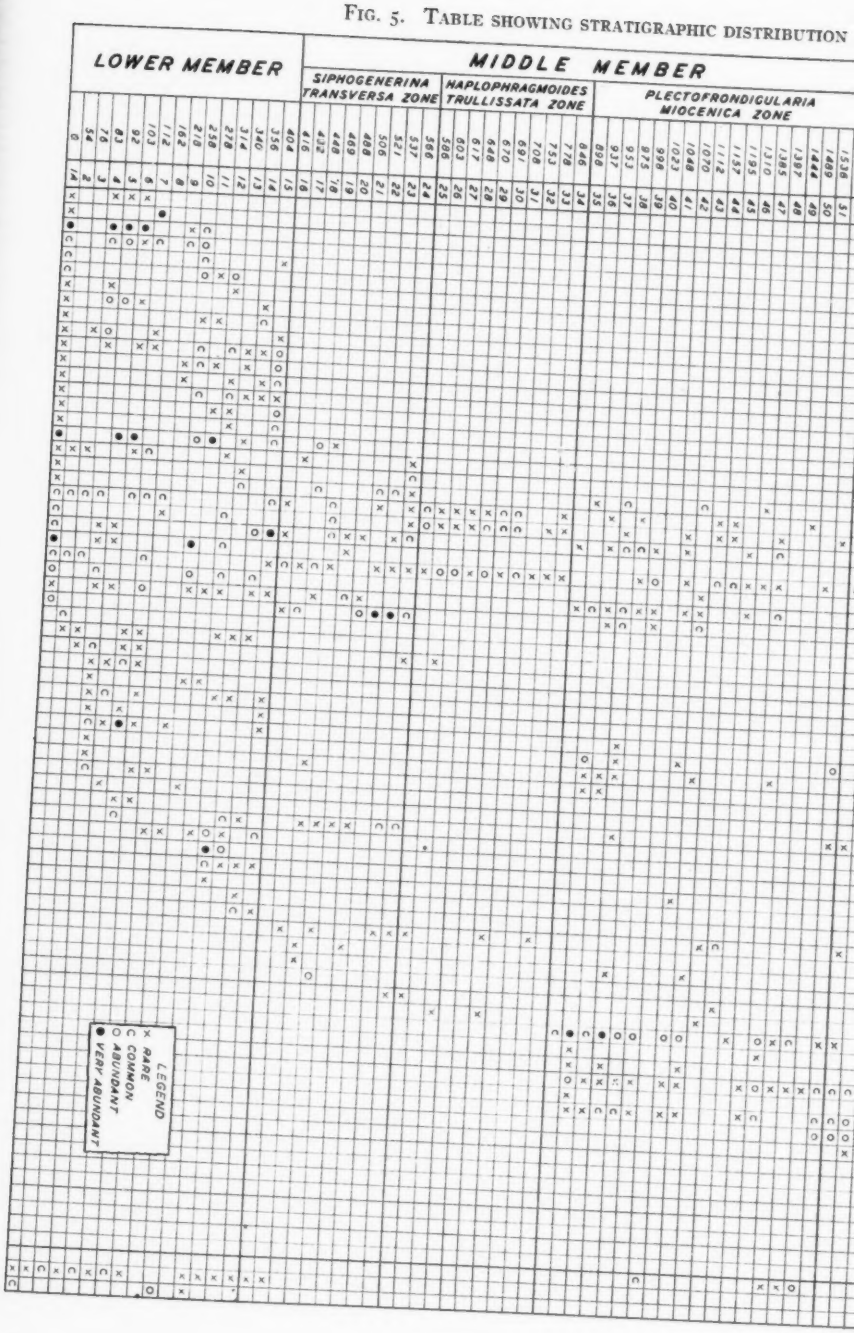
INDEX TO THE SPECIES OF FORAMINIFERA

Species Number	
53	Ammodiscus cf. incertus (d'Orbigny)
6	Angulogerina occidentalis (Cushman)
9	Anomalina glabrata Cushman
19	Bathysiphon sp.
62	Bolivina advena Cushman, var. striatella Cushman
20	Bolivina marginata Cushman
65	Bulimina inflata Seguenza, var. alligata Cushman and Laiming, n. var.

[1]G. D. Hanna, "The Monterey Shale of California at its Type Locality with a Summary of its Fauna and Flora," Bull. Am. Assn. Petroleum Geol. (1928), Vol. 12, p. 969.

[2]Joseph A. Cushman, ."Foraminifera of the Typical Monterey of California," Contrib. Cushman Lab. (1926), Vol. 2, p. 53.

FIG. 5. TABLE SHOWING STRATIGRAPHIC DISTRIBUTION



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BUTION OF FOSSILS FROM THE LOS SAUCES CREEK SECTION.

| LARIA NE | UPPER MEMBER | | |

INDEX TO THE SPECIES OF FORAMINIFERA (*Continued*)

Species Number	
2	Bulimina rinconensis Cushman and Laiming, n. sp.
36	Buliminella curta Cushman
64	Buliminella subfusiformis Cushman
12	Cancris sagra (d'Orbigny)
39	Cassidulina margareta Karrer
7	Cassidulina aff. pulchella d'Orbigny
3	Cibicides americanus (Cushman)
44	Cibicides americanus (Cushman), var. crassiseptus Cushman and Laiming, n. var.
42	Cibicides floridanus (Cushman)
49	Clavulina patens Cushman and Laiming, n. sp.
22	Cyclammina cancellata H. B. Brady, var. obesa Cushman and Laiming, n. var.
21	Cyclammina incisa (Stache)
48	Dentalina cf. guttifera d'Orbigny
66	Dentalina pauperata d'Orbigny
51	Dentalina quadrulata Cushman and Laiming
33	Ellipsolagena ventricosa (A. Silvestri)
5	Eponides affinis (Czjzek)
52	Eponides nanus (Reuss)
54	Gaudryina cf. flintii Cushman
31	Gaudryina gracilis Cushman and Laiming, n. sp.
14	Gaudryina triangularis Cushman
8	Glandulina laevigata d'Orbigny
24	Globigerina bulloides d'Orbigny
26	Globigerina conglomerata Schwager
13	Globobulimina pacifica Cushman
15	Guttulina hughesi Cushman and Laiming, n. sp.
23	Gyroidina soldanii d'Orbigny
25	Haplophragmoides trullissata (H. B. Brady)
29	Hyperammina sp.
56	Lagena costata (Williamson)
59	Lagena hexagona (Williamson), var. scalariformis (Williamson)
34	Lagena substriata Williamson
35	Lagena sulcata (Walker and Jacob), var. apiculata Cushman
32	Marginulina dubia Neugeboren
46	Marginulina subbullata Hantken
68	Nodogenerina advena Cushman and Laiming, n. sp.
57	Nodosaria cf. anomala Reuss
45	Nodosaria arundinea Schwager
38	Nodosaria koina Schwager
60	Nonion costifera (Cushman)
4	Nonion incisa (Cushman)
58	Plectofrondicularia miocenica Cushman
67	Plectofrondicularia miocenica Cushman, var. directa Cushman and Laiming, n. var.
50	Plectofrondicularia sp.
11	Pullenia salisburyi R. E. and K. C. Stewart
37	Pulvinulinella parva Cushman and Laiming, n. sp.
63	Pulvinulinella subperuviana Cushman, var. minuta Cushman and Laiming, n. var.
18	Reophax sp.
40	Robulus nikobarensis (Schwager)
27	Robulus simplex (d'Orbigny)
16	Sigmomorphina reedi Cushman and Laiming, n. sp.
28	Siphogenerina transversa Cushman
47	Siphogenerina sp.

INDEX TO THE SPECIES OF FORAMINIFERA (*Continued*)

Species Number	
10	Spiroplectammina gracilis (von Marck)
30	Trochammina parva Cushman and Laiming, n. sp.
69	Uvigerinella californica Cushman, var. ornata Cushman
61	Uvigerinella obesa Cushman
55	Uvigerinella obesa Cushman, var. impolita Cushman and Laiming, n. var.
41	Uvigerinella sparsicostata Cushman and Laiming, n. sp.
17	Valvulineria casitasensis Cushman and Laiming, n. sp.
43	Virgulina bramlettei Galloway and Morrey
70	Virgulina californiensis Cushman
1	Virgulina floridana Cushman

DESCRIPTION OF SPECIES

FAMILY RHIZAMMINIDAE

GENUS BATHYSIPHON M. SARS, 1872

BATHYSIPHON SP. (?)

Plate 9, figure 1

There are a number of crushed specimens which, in the character of the surface and the structure of the wall, probably belong to this genus. There is however not enough of any of the specimens to determine the adult characters definitely, and no specific name can be assigned to them.

FAMILY HYPERAMMINIDAE

GENUS HYPERAMMINA H. B. BRADY, 1878

HYPERAMMINA SP. (?)

Plate 9, figure 2

Specimens similar to that figured occur in the collections from Los Sauces Creek. They are all collapsed, but evidently are fragments of specimens belonging to this genus. The wall is rather coarsely arenaceous with a considerable amount of cement. None of these is of sufficient size to determine the specific character.

FAMILY REOPHACIDAE

GENUS REOPHAX MONTFORT, 1808

REOPHAX SP. (?)

Plate 9, figure 3

There are a few incomplete specimens, the largest of which has three chambers, but none of these is complete, and specific determination is impossible.

FAMILY AMMODISCIDAE

GENUS AMMODISCUS REUSS, 1861

AMMODISCUS CF. INCERTUS (D'ORBIGNY)

Plate 9, figure 4

A few rather large coarse specimens occur in the material. The preservation of these is not particularly good as to details, and for the present they are assigned with a considerable question to d'Orbigny's species.

FAMILY LITUOLIDAE

GENUS HAPLOPHRAGMOIDES CUSHMAN, 1910

HAPLOPHRAGMOIDES TRULLISSATA (H. B. BRADY)

Plate 9, figures 5 *a*, *b*

The figured specimen illustrates a species of *Haplophragmoides* which is referred to Brady's species. Most of the specimens are much distorted, but enough is preserved so that details may be made out. The specimens are planispiral and apparently bilaterally symmetrical. Chambers are numerous, twelve or more in the final coil in adult specimens. Sutures are prominent and the chambers slightly inflated.

GENUS CYCLAMMINA H. B. BRADY, 1876

CYCLAMMINA INCISA (STACHE)

Plate 9, figures 6 *a*, *b*

Haplophragmium incisum STACHE, *1864*, *Novara*-Exped., Geol. Theil., vol. 1, p. 165, pl. 21, fig. 1.
Cyclammina incisa CHAPMAN, *1926*, New Zealand Geol. Survey, Pal. Bull. No. 11, p. 29, pl. 2, fig. 1.

Test much compressed, umbilicate; chambers eight or ten in the last-formed coil, somewhat irregular in size; sutures slightly depressed, slightly curved, nearly radial; wall finely arenaceous, rather smoothly finished. Diameter slightly more than 1 mm.

This species is recorded from the Tertiary of New Zealand, and seems very close to our specimens from Los Sauces Creek. The California specimens are evidently somewhat compressed, but the figured specimen seems to be fairly well preserved. It occurs also in the Temblor of California.

CYCLAMMINA CANCELLATA H. B. BRADY, VAR. OBESA CUSHMAN AND LAIMING, N. VAR.

Plate 9, figures 10 *a*, *b*

Test differing from the typical in the fewer chambers and the more inflated test; chambers distinct, inflated; sutures distinct, slightly depressed, nearly straight; wall smooth; aperture indistinct. Diameter 1.25 mm.; thickness 0.60 mm.

This variety is much less common than the preceding species, but seems to be very distinct from it in its general characters. The specimens are also much less distorted than the preceding. The figured specimen is somewhat compressed but not greatly so.

Holotype of variety (Cushman Coll. No. 14,366) from the Miocene of Los Sauces Creek, Ventura County, California.

FAMILY TEXTULARIIDAE

GENUS SPIROPLECTAMMINA CUSHMAN, 1927

SPIROPLECTAMMINA GRACILIS (VON MARCK)

Plate 9, figure 7

Textularia gracilis VON MARCK, *1838*, in Roemer, Neues Jahrb. f. Min., p. 384, pl., fig. 14.

Test much compressed, elongate, sides nearly parallel for most of the length, periphery subacute; chambers numerous, distinct, very low, increasing very little in size after the early development, not inflated; sutures distinct, oblique, straight, not depressed, forming an angle of about 20° from the horizontal; wall finely arenaceous with much cement, and smoothly finished. Length 0.75 mm.; breadth 0.30 mm.; thickness 0.12 mm.

EXPLANATION OF PLATE 9

FIGS. 1—*Bathysiphon* sp. (?). ×40.

2—*Hyperammina* sp. (?). ×40.

3—*Reophax* sp. (?). × 40.

4—*Ammodiscus* cf. *incertus* (d'Orbigny). × 40.

5 *a*, *b*—*Haplophragmoides trullissata* (H. B. Brady). × 40. *a*, side view; *b*, oblique view.

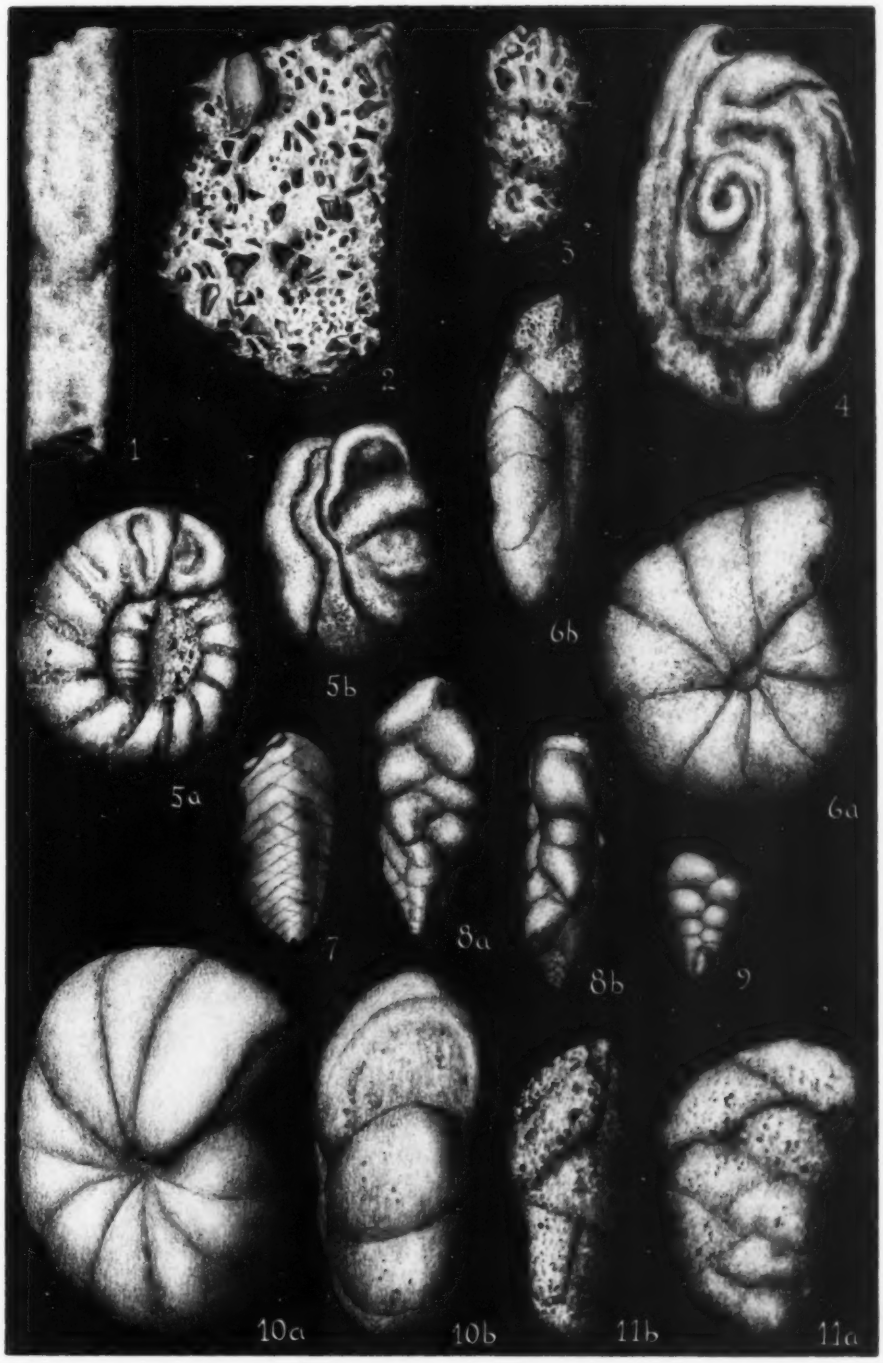
6 *a*, *b*—*Cyclammina incisa* (Stache). × 40. *a* side view; *b*, peripheral view.

7—*Spiroplectammina gracilis* (von Marck). × 40.

8, *a*, *b*, 9—*Gaudryina triangularis* Cushman. × 40. Fig. 8*a*, front view; *b*, side view.

10 *a*, *b*—*Cyclammina cancellata* H. B. Brady, var. *obesa* Cushman and Laiming, n. var. × 40. *a*, side view; *b*, peripheral view.

11 *a*, *b*—*Gaudryina* cf. *flintii* Cushman. × 40. *a*, front view; *b*, side view.



Cushman and Laiming, Miocene Foraminifera

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This species occurs in considerable numbers in the section, and is evidently identical with von Marck's species described from the Oligocene of Germany.

FAMILY VERNEUILINIDAE

GENUS GAUDRYINA D'ORBIGNY, 1839

GAUDRYINA TRIANGULARIS CUSHMAN

Plate 9, figures 8 *a*, *b*, 9

Gaudryina triangularis CUSHMAN, *1911*, U. S. Nat. Mus., Bull. 71, pt. 2, p. 65, figs. 104*a-c* (in text); *1918*, U. S. Nat. Mus., Bull. 103, p. 56, pl. 20, fig. 3; *1919*, Proc. U. S. Nat. Mus., vol. 56, p. 604; *1919*, Carnegie Instit. Washington, Publ. 291, p. 35; *1921*, U. S. Nat. Mus., Bull. 100, vol. 4, p. 148; *1922*, U. S. Geol. Survey, Prof. Paper 129-F, p. 127; *1923*, U. S. Geol. Survey, Prof. Paper 133, p. 21, pl. 3, fig. 5; *1927*, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, p. 138—CUSHMAN AND WICKENDEN, *1929*, Proc. U. S. Nat. Mus., vol. 75, art. 9, p. 2, pl. 1, figs. 1*a*, *b*.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, pl. 51, pl. 1, fig. 2.

Test somewhat longer than broad, for the most part triangular, the angles subacute; early chambers triserially arranged, later ones biserial, few, slightly inflated; sutures distinct, those of the biserial portion nearly at right angles to the periphery, slightly depressed; wall coarsely arenaceous, smoothly finished; aperture, a narrow slit at the base of the inner face of the last-formed chamber. Length 0.85-0.90 mm.; breadth 0.40-0.45 mm.; thickness 0.25 mm.

This species is recorded from the Pacific and in the Pliocene, Miocene and Oligocene of the United States, Cuba and Panama. It is subject to considerable variation in shape according to the number of chambers developed in the biserial portion, this in turn being somewhat dependent on the microspheric and megalospheric forms.

GAUDRYINA CF. FLINTII CUSHMAN

Plate 9, figures 11*a*, *b*

There are numerous specimens in the section similar to that figured. They are always badly crushed, and it is somewhat difficult to make out the complete characters. It has therefore been assigned to this species with some question.

GAUDRYINA GRACILIS CUSHMAN AND LAIMING, N. SP.

Plate 10, figures 1*a*, *b*

Test elongate, slender, periphery rounded, very slightly tapering, greatest breadth toward the apertural end, early portion triserial and somewhat thicker than the remainder of the test in edge view; chambers

numerous, distinct but not inflated, increasing gradually in size as added, but of nearly uniform shape; sutures distinct, very little if at all depressed, oblique, nearly straight, making an angle of about 25° with the horizontal; wall rather coarsely arenaceous, but with a fairly smooth surface. Length of holotype 0.55 mm.; breadth 0.15 mm.; thickness 0.07 mm.

This small slender species is fairly common in certain parts of the section, and while it is somewhat distorted and compressed the characters are fairly well preserved.

Holotype (Cushman Coll. No. 14,374) from the Miocene of Los Sauces Creek, Ventura County, California.

Genus CLAVULINA d'Orbigny, 1826

CLAVULINA PATENS Cushman and Laiming, n. sp.

Plate 10, figures 2*a*, *b*

Test elongate, fairly stout, circular in transverse section, the triserial portion very short; chambers of the early portion indistinct, later ones uniserial, inflated, usually five or six in the adult; sutures in the early portion indistinct, in the later portion distinct and depressed; wall arenaceous with a large proportion of cement, and smoothly finished; aperture terminal, rounded. Length 2.00 mm.; breadth 0.60 mm.

In some respects this species resembles *Clavulina flintiana* which is known from both the Atlantic and Pacific coasts of the United States, and possibly also occurs as a fossil in the late Tertiary of California.

Explanation of Plate 10

Figs. 1 *a*, *b*—*Gaudryina gracilis* Cushman and Laiming, n. sp. × 70. *a*, front view; *b*, side view.

2 *a*, *b*—*Clavulina patens* Cushman and Laiming, n. sp. × 40. *a*, side view; *b*, peripheral view.

3 *a-c*—*Trochammina parva* Cushman and Laiming, n. sp. × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

4 *a*, *b*—*Robulus nikobarensis* (Schwager). × 40. *a*, side view; *b*, peripheral view.

5 *a*, *b*, 6—*Robulus simplex* (d'Orbigny). × 40. Fig. 5*a*, side view; *b*, peripheral view. Fig. 6, side view of larger specimen.

7—*Marginulina dubia* Neugeboren. × 70.

8—*Marginulina subbullata* Hantken. × 70.

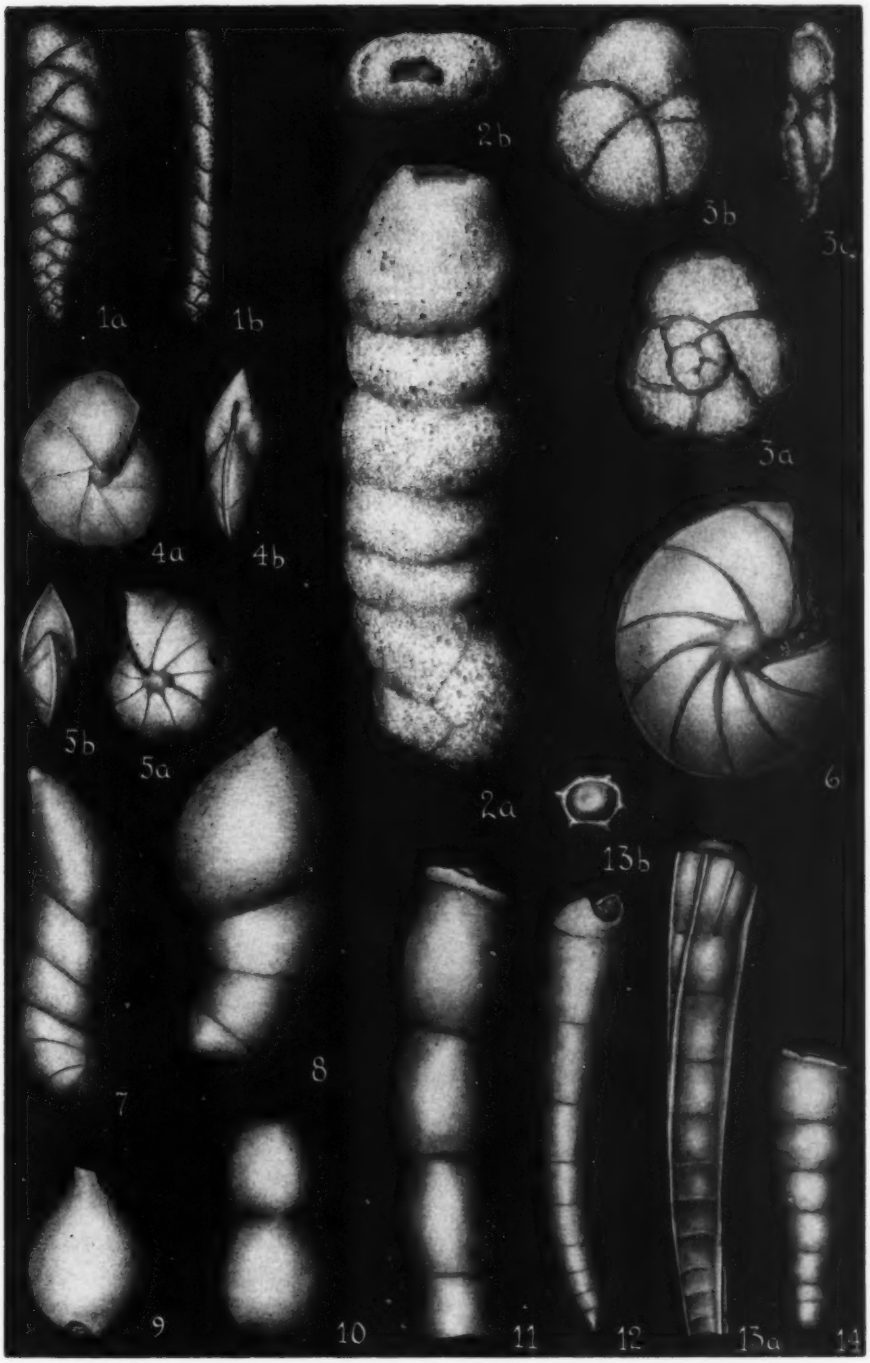
9—*Dentalina* cf. *guttifera* d'Orbigny. × 40.

10—*Nodosaria* cf. *anomala* Reuss. × 70.

11, 12—*Dentalina pauperata* d'Orbigny. × 70.

13 *a*, *b*—*Dentalina quadrulata* Cushman and Laiming, n. sp. × 70. *a*, side view; *b*, end view.

14—*Nodosaria koina* Schwager. × 70.



Cushman and Laiming, Miocene Foraminifera

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Holotype (Cushman Coll. No. 14,375) from the Miocene of Los Sauces Creek, Ventura County, California.

FAMILY TROCHAMMINIDAE

GENUS TROCHAMMINA PARKER AND JONES, 1860

TROCHAMMINA PARVA CUSHMAN AND LAIMING, N. SP.

Plate 10, figures 3*a-c*

Test small, trochoid, dorsal side very slightly convex, ventral side somewhat more rounded and umbilicate, periphery subacute, slightly keeled; chambers few, five making up the adult whorl, increasing rather rapidly in size as added; sutures distinct, flush with the surface on the dorsal side, on the ventral side slightly depressed, very slightly curved; wall arenaceous, but with a considerable amount of cement and fairly smoothly finished; aperture on the ventral side between the periphery and the umbilicus, low. Diameter 0.35 mm.; thickness 0.12 mm.

This is a very small but distinct species with very few chambers, and seems to have a very definite place in the section.

Holotype (Cushman Coll. No. 14,378) from the Miocene of Los Sauces Creek, Ventura County, California.

FAMILY LAGENIDAE

GENUS ROBULUS MONTFORT, 1808

ROBULUS NIKOBARENSIS (SCHWAGER)

Plate 10, figures 4*a*, *b*

Cristellaria nikobarensis SCHWAGER, *1866*, *Novara*-Exped., Geol. Theil., pt. 2, p. 243, pl. 6, fig. 87.
Robulus nikobarensis (SCHWAGER), CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 53, pl. 2, figs. 5, 7.
Cristellaria polita SCHWAGER (not Reuss), *1866*, *Novara*-Exped., Geol. Theil., pt. 2, p. 242, pl. 6, fig. 86.
Robulus cushmani GALLOWAY AND WISSLER, *1927*, Jour. Pal., vol. 1, p. 51, pl. 8, fig. 11.

Test bilaterally symmetrical, keeled, much compressed; chambers usually six to nine in number, of uniform shape, increasing very slightly in size as added, central area with a clear boss of fairly large size; sutures slightly limbate, very slightly curved, flush with the surface; wall smooth; aperture in complete specimens somewhat projecting, radiate at the outer angle above the somewhat concave apertural face. Diameter 0.60-0.75 mm.; thickness 0.20 mm.

The figured specimen does not show the aperture, as it is broken at that point. The apparent aperture in the figure in the medium line is due

to a break in the apertural face, and gives the appearance of an aperture. This species is known from the Pliocene of Kar Nikobar and the Late Tertiary of California.

ROBULUS SIMPLEX (D'ORBIGNY)
Plate 10, figures 5 *a*, *b*, 6

Robulina simplex D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 103, pl. 4, figs. 27, 28.

Test bilaterally symmetrical, umbonate, periphery acute and sometimes slightly keeled; chambers usually nine or ten in the adult coil, increasing gradually in size as added, but of uniform shape, not inflated; sutures distinct, curved, sometimes slightly limbate especially toward the inner end, generally curved, not depressed; wall smooth; aperture radiate, at the peripheral margin slightly projecting with a slight ventral slit at the upper end of the apertural face which is flattened or slightly concave with the sides raised. Diameter 0.50-0.90 mm.; thickness 0.20-0.35 mm.

This form which is fairly common in the collection seems to be identical with the species described by d'Orbigny from the Miocene of the Vienna Basin. This should not be confused with the species described by d'Orbigny from the same locality as *Cristellaria simplex* which is an uncoiled *Marginulina*-like form.

GENUS MARGINULINA D'ORBIGNY, 1826

MARGINULINA DUBIA NEUGEBOREN
Plate 10, figure 7

Marginulina dubia NEUGEBOREN, *1851*, Verh. Mitth. siebenburg. Ver. Nat., vol. 2, p. 120, pl. 4, fig. 1.

Test elongate, the early chambers coiled, later ones in a uniserial series, the sides nearly parallel or slightly lobulate on the inner margin, somewhat compressed, elliptical in section; chambers distinct, the early ones close coiled, the later three to five uncoiled, somewhat overlapping; sutures distinct, very slightly depressed, in the later portion oblique; wall smooth; aperture radiate, at the dorsal side somewhat projecting. Length 0.60 mm.; breadth 0.15 mm.; thickness 0.10 mm.

This species was described by Neugeboren from the Tertiary of Europe, and our figured specimen is close to the original. Neugeboren described similar forms under several different names on the same plate as that where *Marginulina dubia* is first figured. It is probable that several of these at least belong to one species. As the first name he gives is *dubia*, that may be taken as the name for this series.

MARGINULINA SUBBULLATA HANTKEN
Plate 10, figure 8

Marginulina subbullata HANTKEN, *1875* (1876), A magy. kir. földt. int. évkön, vol. 4, p. 39, pl. 4, figs. 9, 10; pl. 5, fig. 9.—CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 3, p. 62, pl. 10, figs. 3*a*, *b*; *1929*, *ibid.*, vol. 5, p. 85, pl. 12, fig. 20.

Test subcylindrical, the initial end broadly rounded, the first three chambers arranged in a loose coil, later two or three uniserial; chambers few, inflated; sutures distinct and depressed; wall smooth and polished; apertural end produced with a small tapering neck and radiate aperture. Length 0.60 mm.; diameter 0.30 mm.

Our specimen seems to fit this species known from the Oligocene of Europe and America as well as from the Miocene of Venezuela.

GENUS DENTALINA D'ORBIGNY, 1826

DENTALINA CF. GUTTIFERA D'ORBIGNY
Plate 10, figure 9

There are fragmentary specimens consisting of a single chamber which are evidently broken from a series. In their general appearance these resemble chambers of the above species, and may be referred to this until such time as complete specimens are found.

DENTALINA PAUPERATA D'ORBIGNY
Plate 10, figures 11, 12

The figured specimens show two incomplete individuals which may be referred to d'Orbigny's species. One shows the early chambers with a distinct basal spine, and the other evidently later chambers which become somewhat inflated, and together these give the general characters of *Dentalina pauperata*. Complete specimens should be found to confirm this identification.

DENTALINA QUADRULATA CUSHMAN AND LAIMING
Plate 10, figures 13*a*, *b*

Dentalina quadrulata CUSHMAN AND LAIMING, *1931*, MS. in Cushman and Parker, Contr. Cushman Lab. Foram. Res., vol. 7, p. 3, pl. 1, figs. 9-11.

Test elongate, slightly tapering, typically with four distinct angles with definitely raised thin costae, in the later portion showing the beginnings of additional costae; chambers distinct, increasing uniformly in size as added, the later ones somewhat more elongate than the earlier; sutures slightly curved, slightly limbate; wall except for the costae smooth. Length 0.90 mm.; diameter 0.15 mm.

This is a distinct species resembling somewhat some of those described from Europe from the Middle Tertiary, but apparently distinct from any of them. None of the specimens shows the complete ends so that the basal characters and those of the aperture cannot be given. There is a tendency for the test to be slightly twisted, and the later growth evidently develops more than the typical four costae.

Genus NODOSARIA Lamarck, 1812

NODOSARIA cf. ANOMALA Reuss

Plate 10, figure 10

There are broken specimens, an example of which is figured here, which have rounded chambers and resemble Reuss's species. No complete specimens were found.

NODOSARIA KOINA Schwager

Plate 10, figure 14

Nodosaria koina Schwager, *1866*, *Novara*-Exped., Geol. Theil, vol. 2, p. 220, pl. 5, fig. 47.—Cushman, *1926*, Contr. Cushman Lab. Foram. Res., vol. 2, p. 56, pl. 7, fig. 6.—Koch, *1926*, Ber. Schweiz. Pal. Ges., vol. 19, p. 725.—Cushman, Stewart and Stewart, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 55, pl. 8, fig. 1.

Test slender, straight or very slightly curved, gently tapering, initial end rounded; chambers numerous, ten or more in the complete adult specimen, inflated, gradually increasing in size as added; sutures distinct but only slightly depressed, more strongly in the later portion; wall smooth, matte; aperture radiate, nearly central. Length of complete specimens about 0.65-0.75 mm.

This species is rare in the material from Los Sauces Creek, but appears to be typical.

NODOSARIA ARUNDINEA Schwager

There are a few fragmentary specimens in our material which may be referred to Schwager's species which was originally described from the Pliocene of Kar Nikobar, and has been recorded from many localities in the Tertiary.

Genus LAGENA Walker and Jacob, 1798

LAGENA SUBSTRIATA Williamson

Plate 11, figure 1

Lagena substriata Williamson, *1848*, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 15, pl. 1, fig. 12.—Cushman, *1923*, U. S. Nat. Mus., Bull. 104, pt. 4, p. 56, pl. 10, fig. 11; *1927*, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, p. 145; *1929*, Contr. Cushman Lab. Foram. Res., vol. 5, p. 68, pl. 11, fig. 4; *1930*, Fla. State Geol. Surv., Bull. 4, p. 31, pl. 5, fig. 14.

Lagena vulgaris Williamson, var. *substriata* Williamson, *1858*, Rec. Foram. Gt. Britain, p. 7, pl. 1, fig. 14.

Test elongate, body of the test longer than broad, basal end rounded, apertural end tapering into an elongate neck; wall ornamented with numerous, fine, longitudinal costae, continuous from the base of the chamber to the neck, sometimes a few on the neck itself. Length 0.30 mm.; diameter 0.18 mm.

This species which is known both as a Recent and Tertiary form has been recorded from off the coast of California and in the Miocene of Florida. It probably is to be found throughout the California late Tertiary.

LAGENA SULCATA (WALKER AND JACOB), VAR. APICULATA CUSHMAN
Plate 11, figure 2

Lagena sulcata, apiculate forms, H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoölogy, vol. 9, pl. 58, figs. 4, 17(?).
Lagena sulcata (WALKER AND JACOB), var. *apiculata* CUSHMAN, *1913*, U. S. Nat. Mus., Bull. 71, pt. 3, p. 23, pl. 9, figs. 3, 4; *1919*, Proc. U. S. Nat. Mus., vol. 56, p. 609; *1921*, U. S. Nat. Mus., Bull. 100, vol. 4, p. 180; *1923*, U. S. Nat. Mus., Bull. 104, pt. 4 p. 58, pl. 11, fig. 2.

Variety differing from the typical in having the apical end drawn out into a stout spine, the apertural end with a tapering cylindrical neck and a phialine lip, usually without other ornamentation, body of the test with numerous longitudinal costae, as in the typical form. Length 0.30 mm.; diameter 0.20 mm.

None of the specimens found have the complete apertural end, but in general appearance and ornamentation this belongs in the above variety.

LAGENA COSTATA (WILLIAMSON)
Plate 11, figure 3

Forms similar to the figured specimen with a few longitudinal costae occur in this Miocene material. The species has already been recorded from the Pliocene of California, and is now living off the coast.

LAGENA HEXAGONA (WILLIAMSON), VAR. SCALARIFORMIS (WILLIAMSON)
Plate 11, figure 4

Specimens occur rarely in the material which have, as is shown in the hexagonal ornamentation, apparently indefinite ventrical rows.

FAMILY POLYMORPHINIDAE

GENUS GUTTULINA D'ORBIGNY, 1826

GUTTULINA HUGHESI CUSHMAN AND LAIMING, N. SP.

Plate 11, figures 5*a*, *b*

Test of medium size, fusiform, greatest width at or below the middle, initial end rounded, apertural end subacute, margin strongly lobulate; chambers few, but little embracing, arranged in a clockwise, quinqueloculine series, each succeeding chamber removed further from the base, distinctly inflated; sutures depressed, distinct; wall smooth; aperture radiate. Length 0.65 mm.; diameter 0.30-0.35 mm.

This species is close to *G. spicaeformis* (Roemer), but the chambers are shorter and much more inflated, and the test is much broader toward the base than in that species. This species is named for Donald D. Hughes, micropaleontologist, of California.

Holotype (Cushman Coll. No. 14,402) from the Miocene of Los Sauces Creek, Ventura County, California.

EXPLANATION OF PLATE 11

FIGS. 1—*Lagena substriata* Williamson. × 70.

2—*Lagena sulcata* (Walker and Jacob), var. *apiculata* Cushman. × 70.

3—*Lagena costata* (Williamson). × 70.

4—*Lagena hexagona* (Williamson), var. *scalariformis* (Williamson). × 70.

5 *a*, *b*—*Guttulina hughesi* Cushman and Laiming, n. sp. × 40. *a*, *b*, side views.

6, 7—*Sigmomorphina reedi* Cushman and Laiming, n. sp. × 40. Fig. 6, holotype.

8—*Glandulina laevigata* d'Orbigny. × 70.

9 *a*, *b*—*Nonion costifera* (Cushman). × 40. *a*, side view; *b*, peripheral view.

10 *a*, *b*—*Nonion incisa* (Cushman). × 40. *a*, side view; *b*, peripheral view.

11—*Plectofrondicularia miocenica* Cushman. × 70.

12—*Plectofrondicularia miocenica* Cushman, var. *directa* Cushman and Laiming, n. var. × 70.

13—*Plectofrondicularia* sp. (?). × 70.

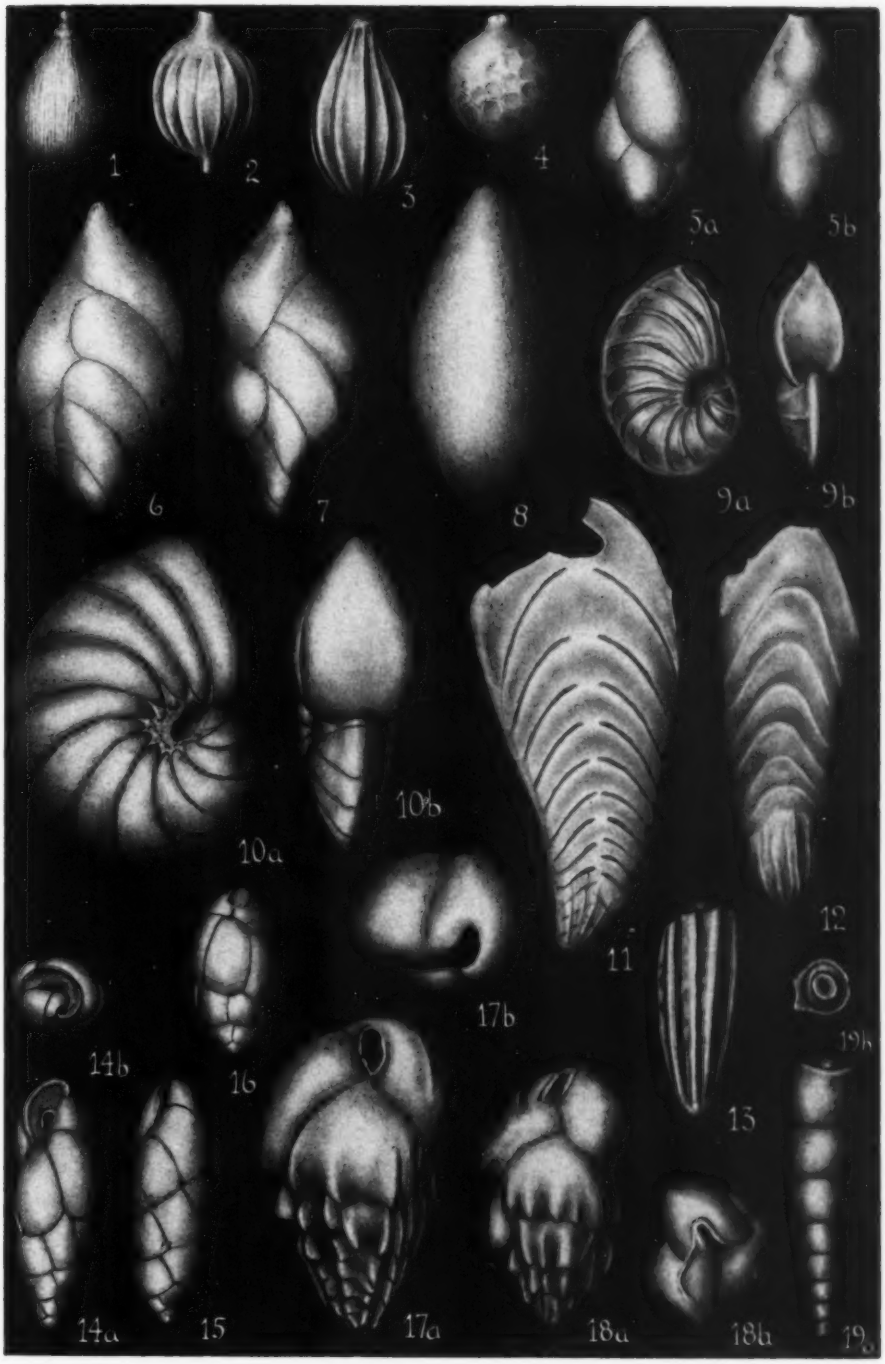
14 *a*, *b*—*Buliminella subfusiformis* Cushman. × 70. *a*, side view; *b*, apertural view.

15, 16—*Buliminella curta* Cushman. × 70. Fig. 15, adult specimen with straight sides. Fig. 16, young specimen.

17 *a*, *b*—*Bulimina inflata* Seguenza, var. *alligata* Cushman and Laiming, n. var. × 70. *a*, side view; *b*, apertural view.

18 *a*, *b*—*Bulimina rinconensis* Cushman and Laiming, n. sp. × 70. *a*, side view; *b*, apertural view.

19 *a*, *b*—*Nodogenerina advena* Cushman and Laiming, n. sp. × 70. *a*, side view; *b*, apertural view.



Cushman and Laiming, Miocene Foraminifera

GENUS SIGMOMORPHINA CUSHMAN AND OZAWA, 1928

SIGMOMORPHINA REEDI CUSHMAN AND LAIMING, N. SP.

Plate 11, figures 6, 7

Test irregularly rhombic, the base rounded, apertural end narrowed and produced, compressed, more or less twisted, margin rounded, slightly lobulate; chambers compressed, elongate, arranged in a clockwise, sigmoid series, each succeeding chamber removed further from the base; sutures very slightly if at all depressed, distinct; wall smooth; aperture radiate. Length 1.00 mm.; breadth 0.45-0.55 mm.

This is a very distinctive species, somewhat remotely resembling *Sigmomorphina vaughani* Cushman and Ozawa, but is a much more elongate species, with a more lobulate periphery. This species is named for Ralph D. Reed, geologist, of California.

Holotype (Cushman Coll. No. 14,405) from the Miocene of Los Sauces Creek, Ventura County, California.

GENUS GLANDULINA D'ORBIGNY, 1826

GLANDULINA LAEVIGATA D'ORBIGNY

Plate 11, figure 8

Nodosaria (*Glandulina*) *laevigata* D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 252, No. 1, pl. 10, figs. 1-3.

Glandulina laevigata D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 29, pl. 1, figs. 4, 5.—CUSHMAN AND OZAWA, *1930*, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 143, pl. 40, figs. *1a*, *b*.

Test fusiform, the initial end very acute and often with spine in the microspheric form, obtuse in the megalospheric form, circular in cross section; chambers inflated, much overlapping, arranged at first in a biserial series, abruptly becoming uniserial in the microspheric form, entirely uniserial in the megalospheric form; sutures not depressed, distinct; wall smooth, rather thick; aperture radiate. Length 0.60 mm.; diameter 0.25 mm.

This is a common species in this Miocene material, and many of the specimens show the sutures very distinctly. The figured specimen did not show the early sutures, but some of the microspheric specimens show distinctly the biserial chambers in the early stages.

FAMILY NONIONIDAE

GENUS NONION MONTFORT, 1808

NONION INCISA (CUSHMAN)

Plate 11, figures 10*a*, *b*

Nonionina incisa CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Res., vol. 1, p. 90, pl. 13, figs. 3*a-c*; *1926*, *ibid.*, vol. 2, p. 65.
Nonion incisa (CUSHMAN), CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 60.

Test longer than broad, periphery acute, composed of numerous chambers, twelve to fifteen in the last-formed coil, slightly umbilicate; sutures distinct, deeply incised, curved, forming an acute angle with the periphery; wall smooth; in apertural view the apertural face broad, slightly convex; the aperture an elongate, narrow, arched opening at the base of the apertural face between it and the preceding coil. Length 1.00 mm.; breadth 0.80 mm.; thickness 0.40 mm.

This species originally described from the Monterey Miocene of California occurs toward the base of the Los Sauces section. It is also recorded from the Miocene of Humbolt County, California.

NONION COSTIFERA (CUSHMAN)

Plate 11, figures 9*a*, *b*

Nonionina costifera CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Res., vol. 1, p. 90, pl. 13, figs. 2*a-c*; *1926*, *ibid.*, vol. 2, 1926, p. 65.
Nonion costifera (CUSHMAN), CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 60, pl. 3, figs. 13*a*, *b*.

Test longer than broad, periphery acute, almost keeled, composed of numerous chambers, as many as twenty in the last-formed coil, slightly umbilicate; sutures distinct, limbate, slightly raised above the general surface, increasing in thickness and height toward the umbilicus, forming an acute angle with the periphery; in apertural view heart-shaped or broadly triangular, flattened or slightly concave, the aperture a very small semicircular opening at the base of the apertural face between it and the preceding coil. Length 0.70 mm.; breadth 0.50 mm.; thickness 0.25 mm.

This species originally described from the Monterey Miocene of California is also recorded from the Miocene of Humboldt County, California.

FAMILY HETEROHELICIDAE

GENUS PLECTOFRONDICULARIA LIEBUS, 1903

PLECTOFRONDICULARIA MIOCENICA CUSHMAN

Plate 11, figure 11

Plectofrondicularia miocenica CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Res., vol. 2, p. 58, pl. 7, figs. 10, 11; pl. 8, figs. 11, 12.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 63, pl. 4, fig. 9.

Test elongate, narrow, gradually tapering, very much compressed, periphery acute, keeled; chambers numerous, distinct, elongate, early ones biserial, alternating; sutures distinct, slightly depressed, curved; wall very thin except in the earlier chambers which are thickened, ornamented by a few longitudinal costae, strongest over the proloculum thence gradually spreading and decreasing in size. Length 0.85 mm.; breadth 0.40 mm.

This species was originally described from the Monterey Miocene of San Luis Obispo County, California, and has been recorded also from Humboldt County, California. In its typical form it is somewhat spreading as it develops, whereas the following variety has the sides nearly parallel.

PLECTOFRONDICULARIA MIOCENICA CUSHMAN, VAR. DIRECTA CUSHMAN AND LAIMING, N. VAR.

Plate 11, figure 12

Variety differing from the typical in the shape of the test which is narrow, and has sides nearly parallel for most of the length. Length 0.70 mm.; breadth 0.20-0.25 mm.

This variety seems to be very distinct in the Los Sauces Creek material, has a distinct place at the top of the section, and therefore seems worthy of distinction as a varietal form.

Holotype of variety (Cushman Coll. No. 14,460) from the Miocene of Los Sauces Creek, Ventura County, California.

PLECTOFRONDICULARIA SP. (?)

Plate 11, figure 13

There are a very few broken specimens representing the basal portion of a species with very straight raised costae, but no complete specimens were found, and the specific identification must await the finding of more and better material.

GENUS NODOGENERINA CUSHMAN, 1927

NODOGENERINA ADVENA CUSHMAN AND LAIMING, N. SP.
Plate 11, figures 19*a*, *b*

Test elongate, tapering, circular in transverse section; chambers distinct, inflated, closely set, and slightly overlapping, of fairly uniform shape, increasing gradually in size as added, later ones slightly higher than the earlier ones; sutures distinct, depressed; wall smooth, or showing traces of slight roughenings in longitudinal lines; aperture elliptical, extended, with a slight lip. Length 0.60-0.70 mm.; diameter 0.12-0.15 mm.

This is a small but apparently distinctive species with the chambers close-set.

Holotype (Cushman Coll. No. 14,397) from the Miocene of Los Sauces Creek, Ventura County, California.

FAMILY BULIMINIDAE

GENUS BULIMINELLA CUSHMAN, 1911

BULIMINELLA SUBFUSIFORMIS CUSHMAN
Plate 11, figures 14 *a*, *b*

Buliminella subfusiformis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, p. 33, pl. 5, fig. 12; *1926*, *ibid.*, vol. 2, p. 55.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 64, pl. 4, figs. 8*a*, *b*.

Test spiral, much elongate, subcylindrical, early portion tapering, sides for most of the test nearly parallel, periphery lobulate; chambers numerous, inflated, distinct, three or four making up a coil; sutures distinct, depressed; wall smooth, very finely punctate; aperture narrow, elongate. Length 0.45 mm.; diameter 0.75 mm.

This species was originally described from the Monterey Miocene of San Luis Obispo County, California, and is known also from Humboldt County, California.

BULIMINELLA CURTA CUSHMAN
Plate 11, figures 15, 16

Buliminella curta CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 33, pl. 5, fig. 13; *1930*, Fla. State Geol. Survey, Bull. 4, p. 43, pl. 8, fig. 4.

Test an elongate spiral, tapering or fusiform, initial end rounded, thence rapidly increasing in diameter until well toward the apertural end, periphery slightly lobulate, spiral suture well marked; chambers numerous, five or six making up a whorl in the adult, distinct, inflated; sutures distinct, slightly depressed; wall smooth, very finely perforate;

aperture comma-shaped in a slightly concave depression of the last-formed chamber. Length 0.45 mm.; diameter 0.14—0.16 mm.

This species was originally described from the Monterey Miocene of California, and is also recorded from the Miocene of Florida. In both regions the test usually increases in breadth toward the apertural end, but there are in all the series a few specimens which are more elongate, and the later chambers fail to increase the diameter of the test leaving the sides nearly parallel.

Genus BULIMINA d'Orbigny, 1826

BULIMINA INFLATA Seguenza, var. ALLIGATA Cushman and Laiming, n. var.

Plate 11, figures 17*a*, *b*

Variety differing from the typical in the costae which are in very definite longitudinal lines, but broken at the sutures; the chambers are somewhat inflated but not strongly so. Length 0.60 mm.; diameter 0.35 mm.

This variety is very distinctive in the section, and has a limited range. It is more distinctive in the material than can be shown by description and figure.

Holotype of variety (Cushman Coll. No. 14,429) from the Miocene of Los Sauces Creek, Ventura County, California.

BULIMINA RINCONENSIS Cushman and Laiming, n. sp.

Plate 11, figures 18*a*, *b*

Test about twice as long as broad, with the greatest breadth toward the apertural end; chambers distinct, inflated, angular, especially in the end view; sutures distinct, deeply depressed; wall ornamented toward the base of each chamber by very bluntly pointed, low, broad, rounded costae; aperture fairly large, elongate, with a slight lip. Length 0.50 mm.; diameter 0.25 mm.

This is a distinctive species, and has a very definite range in the section. It may be distinguished by the angular form and the peculiarity of the ornamentation which gives the impression of a crudely carved specimen, not with the usual clear-cut character seen in this genus.

Holotype (Cushman Coll. No. 14,427) from the Miocene of Los Sauces Creek, Ventura County, California.

GENUS GLOBOBULIMINA CUSHMAN, 1927

GLOBOBULIMINA PACIFICA CUSHMAN

Plate 12, figures 1*a*, *b*

Globobulimina pacifica CUSHMAN, *1927*, Contr. Cushman Lab. Foram. Res., vol. 3 p. 67, pl. 14, fig. 12; *1927*, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, p. 153, pl. 3, fig. 1.—GALLOWAY AND WISSLER, *1927*, Jour. Pal., vol. 1, p. 74, pl. 11, fig. 18.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 1, p. 66, pl. 5, fig. 4.—CUSHMAN AND MOYER, *1930*, Contr. Cushman Lab. Foram. Res., vol. 6, p. 57.

Test subglobular in the adult, usually widest toward the initial end, the last three chambers making up the exterior by enclosing the preceding ones; sutures distinct, slightly depressed; wall very thin, finely perforate, smooth; aperture loop-shaped with a slight border, a broad apertural tooth or plate, and an internal spiral tube. Length 0.50 mm.; breadth 0.30 mm.; thickness 0.22-0.25 mm.

This species is common in the late Tertiary of California, and occurs also living off the coast.

GENUS VIRGULINA D'ORBIGNY, 1826

VIRGULINA CALIFORNIENSIS CUSHMAN

Plate 12, figures 2*a*, *b*

Virgulina californiensis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 32, pl. 5, figs. 11*a-c*; *1926*, *ibid.*, vol. 2, p. 54.

Test slightly more than twice as long as broad; early chambers spiral, later ones biserial, not twisted, periphery broadly rounded, the

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EXPLANATION OF PLATE 12

FIGS. 1 *a*, *b*—*Globobulimina pacifica* Cushman. × 70. *a*, side view; *b*, apertural view.

2 *a*, *b*—*Virgulina californiensis* Cushman. × 70. *a*, side view; *b*, apertural view.

3 *a*, *b*—*Virgulina floridana* Cushman. × 70. *a*, *b*, opposite sides.

4 *a*, *b*—*Virgulina bramlettei* Galloway and Morrey. × 70. *a*, front view; *b*, side view.

5—*Bolivina advena* Cushman, var. *striatella* Cushman. × 70.

6-8—*Bolivina marginata* Cushman. ×70.

9 *a*, *b*—*Uvigerinella californica* Cushman, var. *ornata* Cushman. × 70. *a*, side view; *b*, apertural view.

10 *a*, *b*—*Uvigerinella obesa* Cushman. × 70. *a*, side view; *b*, apertural view.

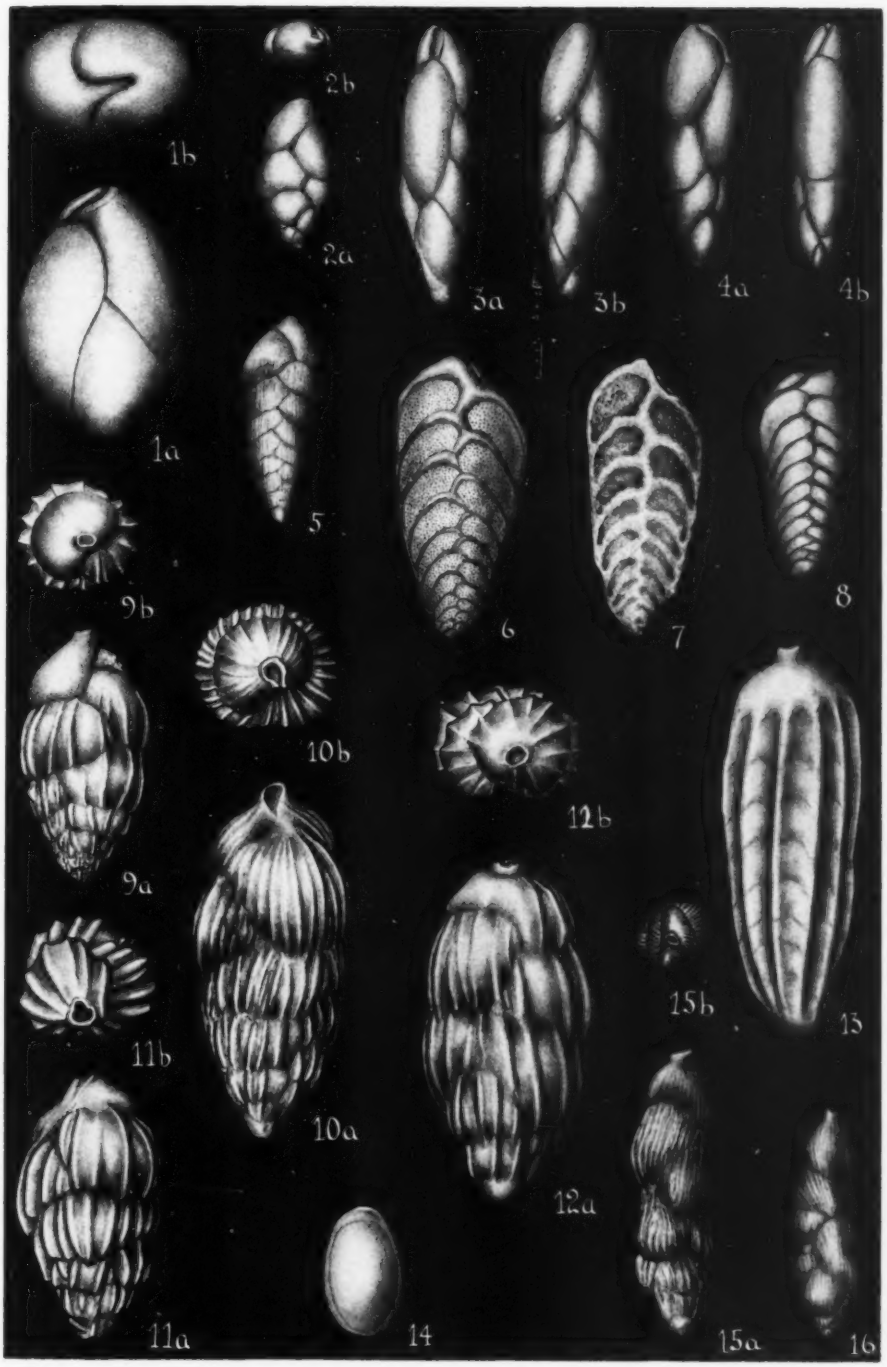
11 *a*, *b*—*Uvigerinella obesa* Cushman, var. *impolita* Cushman and Laiming, n. var. × 70. *a*, side view; *b*, apertural view.

12 *a*, *b*—*Uvigerinella sparsicostata* Cushman and Laiming, n. sp. × 70. *a*, side view; *b*, apertural view.

13—*Siphogenerina transversa* Cushman. × 40.

14—*Ellipsolagena ventricosa* (A. Silvestri). × 70.

15 *a*, *b*, 16—*Angulogerina occidentalis* (Cushman). × 70. Fig. 15*a*, side view; *b*, apertural view.



Cushman and Laiming, Miocene Foraminifera

last three chambers making up nearly half the test, initial end subacute, apertural end broadly rounded, early chambers small, indistinct, later ones inflated, very distinct, biserial; sutures of the early portion indistinct, later ones very distinct, depressed; wall smooth but distinctly punctate; aperture comma-shaped. Length 0.30 mm.; breadth 0.15 mm.; thickness 0.08 mm.

This species originally described from the Monterey Miocene of San Luis Obispo County, California, also occurs in typical form in the top of the section in the Los Sauces Creek material.

VIRGULINA FLORIDANA CUSHMAN

Plate 12, figures 3*a*, *b*

Virgulina floridana CUSHMAN, *1920*, U. S. Geol. Survey Prof. Paper 128-B, p. 68, pl. 11, fig. 1.

Test elongate, fusiform or slightly tapering, greatest diameter toward the apertural end, periphery somewhat lobulate; chambers elongate, distinct, inflated; sutures distinct, depressed; wall smooth; aperture comma-shaped. Length 0.50 mm.; breadth 0.15 mm.

This species was originally described from the Miocene of Oak Grove marl, Yellow River, Santa Rosa County, Florida. The material from Los Sauces Creek seems to be very close indeed to the Florida species.

VIRGULINA BRAMLETTEI GALLOWAY AND MORREY

Plate 12, figures 4*a*, *b*

Virgulina bramlettei GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, p. 37, pl. 5, fig. 14.—CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Res., vol. 5, p. 94, pl. 13, fig. 30.—CUSHMAN AND MOYER, *1930*, Contr. Cushman Lab. Foram. Res., vol. 6, p. 57, pl. 8, fig. 2.

Test elongate, somewhat fusiform, greatest breadth at or above the middle; chambers distinct, somewhat inflated; sutures distinct, slightly depressed; wall smooth but distinctly perforate; aperture narrow, comma-shaped. Length 0.40-0.45 mm.; breadth 0.15 mm.; thickness 0.10 mm.

This seems to be the same as the species described from the Miocene of Ecuador, and known also from the Miocene of Venezuela. It also occurs living off the coast of California. This species is peculiar in the shape and arrangement of the chambers, the last three making up a large proportion of the test.

GENUS BOLIVINA D'ORBIGNY, 1839

BOLIVINA ADVENA CUSHMAN, VAR. STRIATELLA CUSHMAN

Plate 12, figure 5

Bolivina advena CUSHMAN, var. *striatella* CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 30, pl. 5, figs. *3a, b; 1926, ibid.*, vol. 2, p. 54.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 68.

Variety differing from the typical in the longer, more tapering form, the initial end subacute, about nine chambers making up the last half of the test; sutures somewhat distinct, very slightly depressed; wall finely perforate, surface of the early portion ornamented with very fine, numerous, longitudinal costae, the later portion smooth. Length 0.40 mm.; breadth 0.18 mm.

This species originally described from the Monterey Miocene of San Luis Obispo County, California, also occurs in the late Tertiary of northern California and probably elsewhere.

BOLIVINA MARGINATA CUSHMAN

Plate 12, figures 6-8

Bolivina marginata CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 48, pl. 10, fig. 1; *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, p. 30, pl. 5, figs. *5a, b; 1930*, Fla. State Geol. Survey, Bull. 4, p. 45, pl. 8, figs. *9a, b*.

Test much compressed, of medium size for the genus, periphery acute, keeled throughout or sometimes obsolete at the apertural end; sutures usually distinctly limbate, oblique; chambers numerous, distinct, seven or eight making up the last half of the test, earlier ones long and narrow, later ones much higher; wall thin, rather coarsely perforate, surface smooth; aperture elongate, narrow. Length 0.50 mm.; breadth 0.20-0.22 mm.

This species originally described from the Miocene of Florida occurs also in the Monterey Miocene of California. There is considerable difference in the appearance of this species in the different parts of the Los Sauces Creek section depending on the state of preservation of the material. Plate 12, figure 6 shows a very well preserved specimen with the wall clear and but little changed. Plate 12, figure 7, shows a specimen which is much mineralized, giving a very opaque appearance to the test, and very easily distinguishes that part of the section in which it occurs. Plate 12, figure 8 shows another form in which the test is more or less opaque, but otherwise specimens are fairly well preserved. In all three specimens the general form and especially the shape of the chambers and curvature of the sutures are constant characters.

GENUS UVIGERINELLA CUSHMAN, 1926

UVIGERINELLA CALIFORNICA CUSHMAN, VAR. ORNATA CUSHMAN

Plate 12, figures 9*a*, *b*

Uvigerina (*Uvigerinella*) *californica* CUSHMAN, var. *ornata* CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Res., vol. 2, p. 59, pl. 8, figs. 1*a-c*, 6.
Uvigerinella californica CUSHMAN, var. *ornata* CUSHMAN.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 68, pl. 5, fig. 9.

Test elongate, fusiform, greatest width toward the apertural end; chambers distinct, inflated, slightly twisted; sutures distinct, depressed; wall ornamented with numerous, distinct, longitudinal costae; aperture with a slight neck, somewhat compressed, in well preserved specimens with a slight lip. Length 0.45 mm.; breadth 0.22 mm.

This seems identical with the form previously described from the Monterey Miocene of San Luis Obispo County, California, and also recorded from Humboldt County, California.

UVIGERINELLA OBESA CUSHMAN

Plate 12, figures 10*a*, *b*

Uvigerina (*Uvigerinella*) *obesa* CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Res., vol. 2, p. 59, pl. 8, figs. 3*a-c*, 7.

Test elongate, fusiform, greatest width above the middle; chambers numerous, inflated; sutures deeply depressed, the posterior portion of the later chambers overhanging; wall with numerous fine costae, those of each chamber independent of adjacent ones; aperture terminal, with a short neck and somewhat phialine lip usually open at the inner end. Length 0.65 mm.; diameter 0.30 mm.

This species occurs in typical form in the Los Sauces Creek section, and specimens are very similar to those already described from the Monterey Miocene of San Luis Obispo County, California. The apertural end has a definite neck, but opens toward the inner margin of the chamber.

UVIGERINELLA OBESA CUSHMAN, VAR. IMPOLITA CUSHMAN AND LAIMING, N. VAR.

Plate 12, figures 11*a*, *b*

Variety differing from the typical in the much coarser costae of the surface, the chambers slightly more inflated, and the sutures deeper. Length 0.50 mm.; diameter 0.28 mm.

This variety seems very distinct in the Los Sauces Creek section, and there is easily distinguished.

Holotype of variety (Cushman Coll. No. 14,454) from the Miocene of Los Sauces Creek, Ventura County, California.

UVIGERINELLA SPARSICOSTATA CUSHMAN AND LAIMING, N. SP.
Plate 12, figures 12*a*, *b*

Test fusiform, somewhat compressed, slightly lobulate at the periphery; chambers fairly distinct, not greatly inflated, somewhat biserially arranged in the later portion; sutures distinct, but only slightly depressed; wall ornamented with numerous coarse costae, those of adjacent chambers being independent of one another; aperture with a distinct neck and a slight lip. Length 0.60 mm.; breadth 0.30 mm.; thickness 0.20 mm.

This species seems to be very distinct from the others present in this section, and may be distinguished by the compression of the test, the coarse ornamentation, and the small amount of inflation of the chambers.

Holotype (Cushman Coll. No. 14,447) from the Miocene of Los Sauces Creek, Ventura County, California.

GENUS SIPHOGENERINA SCHLUMBERGER, 1883

SIPHOGENERINA TRANSVERSA CUSHMAN
Plate 12, figure 13

Siphogenerina raphanus (PARKER AND JONES), var. *transversus* CUSHMAN, *1918*, U. S. Nat. Mus., Bull. 103, p. 64, pl. 22, fig. 8; *1926*, Proc. U. S. Nat. Mus., vol. 67, Art. 25, p. 6, pl. 1, fig. 6.—NUTTALL, *1928*, Quart. Journ. Geol. Soc., vol. 84, p. 94, pl. 6, fig. 14.—CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Res., vol. 5, p. 95.

Test subcylindrical, later chambers uniserial, early ones spirally arranged; chambers fairly distinct, short; sutures distinct, slightly depressed; wall ornamented with a few high lamellate, longitudinal costae; aperture with a short cylindrical neck. Length 1.30 mm.; diameter 0.45 mm.

This species was originally described from the Tertiary of the Panama Canal Zone, has been recorded by Nuttall from Trinidad, and is also known from the Miocene of Venezuela.

GENUS ANGULOGERINA CUSHMAN, 1927

ANGULOGERINA OCCIDENTALIS (CUSHMAN)
Plate 12, figures 15 *a*, *b*, 16

Uvigerina angulosa CUSHMAN (not Williamson), *1922*, Carnegie Inst. Washington, Publ. 311, p. 34, pl. 5, figs. 3, 4.
Uvigerina occidentalis CUSHMAN, *1923*, U. S. Nat. Mus., Bull. 104, pt. 4, p. 169.
Angulogerina occidentalis CUSHMAN, *1930*, Fla. State Geol. Survey, Bull. 4, p. 50, pl. 9, figs. 8, 9.

Test minute, elongate, triangular in transverse section, the periphery somewhat lobulate; chambers distinct, those of the last-formed

portion becoming more distinct and remote; sutures distinct and depressed; wall ornamented with longitudinal costae, the last-formed chambers sometimes with the ornamentation wanting; apertural end drawn out into a short tubular neck and slight phialine lip. Length 0.40-0.50 mm.; diameter 0.12-0.15 mm.

The Los Sauces Creek specimens seem to be identical with the above species which is already known from the Miocene of Florida, and is living off the coast of Florida at the present time.

Family ELLIPSOIDINIDAE

Genus ELLIPSOLAGENA A. Silvestri, 1923

ELLIPSOLAGENA VENTRICOSA (A. Silvestri)

Plate 12, figure 14

The figured specimen represents a small species which seems very close to that described by Silvestri. The aperture is somewhat at one side, elongate, slit-like. Length 0.25 mm.; breadth 0.15 mm.

Family ROTALIIDAE

Genus VALVULINERIA Cushman, 1926

VALVULINERIA CASITASENSIS Cushman and Laiming, n. sp.

Plate 13, figures 1*a-c*

Test unequally biconvex, periphery in the early portion subacute, later broadly rounded; chambers distinct, the later ones becoming progressively more inflated; sutures very distinct, the early ones somewhat limbate, later ones depressed; wall smooth, but distinctly perforate; aperture ventral, beneath the overhanging lip above the umbilicus. Length 0.80 mm.; breadth 0.65 mm.; thickness 0.40 mm.

This is a very distinctly marked species with the earlier portion having the chambers not inflated, and with very distinct limbate sutures. Later the chambers become inflated, and the sutures distinctly depressed. Both sides are almost completely involute to the center.

Holotype (Cushman Coll. No. 14,471) from the Miocene of Los Sauces Creek, Ventura County, California.

GENUS GYROIDINA D'ORBIGNY, 1826

GYROIDINA SOLDANII D'ORBIGNY

Plate 13, figures 2*a-c*

Rotalia (*Gyroidina*) *soldanii* D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 278; Modèles No. 36.

Gyroidina soldanii CUSHMAN, *1927*, Bull. Scripps Inst. Oceanography, Tech. Ser., vol. 1, p. 162.—CUSHMAN, STEWART AND STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, p. 72, pl. 6, figs. 1*a-c*.

This species is widely distributed, and does not vary greatly. It occurs off the western coast of America and in the Tertiary of California as well as in many other regions. The form figured seems to be fairly typical.

GENUS EPONIDES MONTFORT, 1808

EPONIDES AFFINIS (CZJZEK)

Plate 13, figures 8*a-c*

Rotalina affinis CZJZEK, *1848*, Haidinger's Nat. Abhandl., vol. 2, p. 144, pl. 12, figs. 36-38.

Test nearly equally biconvex, periphery subacute with a blunt keel, ventral side umbilicate; chambers distinct, six or seven in the last-formed whorl, increasing gradually in size as added, of uniform shape throughout, very slightly inflated on the ventral side; sutures distinct, limbate, on the dorsal side strongly oblique, slightly curved, ventrally curved, ending about the umbilicus in a thickened ring; wall smooth except for the thickening on the ventral side; aperture ventral between the umbilicus and the periphery. Diameter 0.60 mm.; thickness 0.25 mm.

EXPLANATION OF PLATE 13

FIGS. 1 *a-c*—*Valvulineria casitasensis* Cushman and Laiming, n. sp. × 40. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

2 *a-c*—*Gyroidina soldanii* d'Orbigny. × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

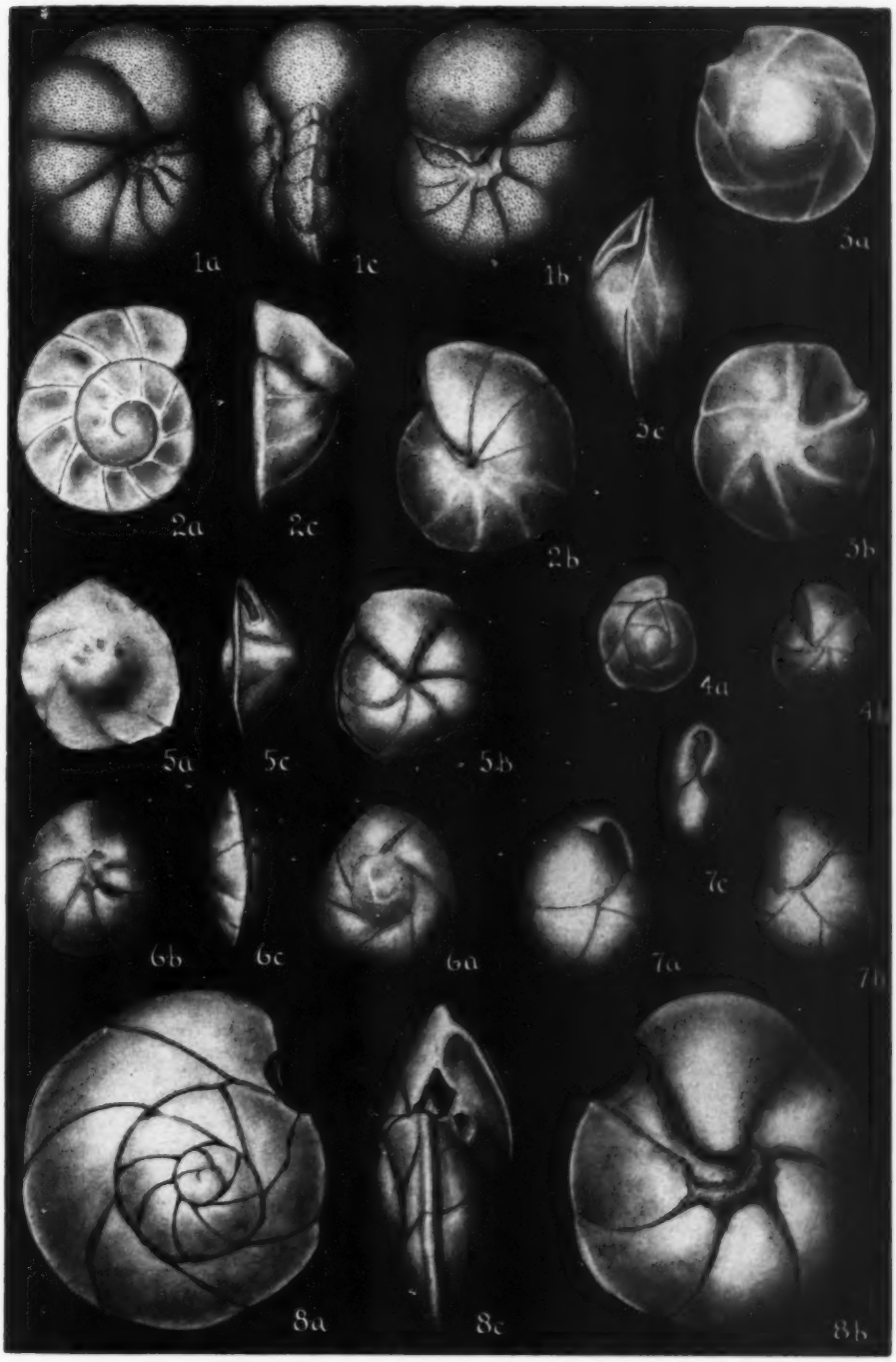
3 *a-c*, 4 *a*, *b*—*Eponides nanus* (Reuss). × 70. Fig. 3*a*, dorsal view; *b*, ventral view; *c*, peripheral view. Fig. 4*a*, dorsal view; *b*, ventral view.

5 *a-c*—*Pulvinulinella parva* Cushman and Laiming, n. sp. × 100. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

6 *a-c*—*Pulvinulinella subperuviana* Cushman, var. *minuta* Cushman and Laiming, n. var. × 100. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

7 *a-c*—*Cassidulina margareta* Karrer. × 100. *a*, *b*, opposite sides; *c*, peripheral view.

8 *a-c*—*Eponides affinis* (Czjzek). × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.



Cushman and Laiming, Miocene Foraminifera

The Los Sauces Creek specimens are very similar to those described by Czjzek from the Miocene of Europe. This is a very distinctive species with well defined chambers and very clearly indicated sutures.

EPONIDES NANUS (REUSS)

Plate 13, figures 3, 4

Rotalina nana REUSS, *1850*, Denkschr. Akad. Wiss. Wien, vol. 1, p. 371, pl. 46, fig. 23.

Test strongly biconvex, periphery acute, slightly keeled; chambers distinct, five or six making up the last-formed whorl, of uniform shape and increasing very slightly in size as added; sutures fairly distinct, very slightly limbate, on the dorsal side strongly oblique, nearly straight, ventrally slightly curved, tangential, flush with the surface on both sides, on the ventral side ending in a clear area at the umbilicus; wall smooth; aperture elongate, narrow, between the periphery and the umbilicus on the ventral side. Diameter 0.35 mm.; thickness 0.20 mm.

This small but distinctive species is identical with that described by Reuss from the Miocene of the Vienna Basin.

GENUS CANCRIS MONTFORT, 1808

CANCRIS SAGRA (D'ORBIGNY)

Plate 14, figures *3a-c*

Rotalina sagra D'ORBIGNY, *1839*, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, "Foraminifères," p. 77, pl. 5, figs. 13-15.

Pulvinulina sagra CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 65, pl. 22, fig. 3; pl. 23, fig. 1.

Cancris sagra CUSHMAN, *1930*, Fla. State Geol. Survey, Bull. 4, p. 56, pl. 11, figs. *4a-c*.

Test longer than broad, biconvex, the ventral side more strongly convex than the dorsal, periphery acute; chambers few, six to seven in the adult whorl, increasing rapidly in size as added; sutures slightly depressed on the dorsal side, strongly on the ventral, gently curved; wall smooth; an elliptical area of clearer, thinner wall near the aperture which is below a slight lip on the ventral side. Length 0.65 mm.; breadth 0.40 mm.; thickness 0.25 mm.

There are a few specimens which seem identical with this species as it occurs in the Miocene of Florida and living in the West India region.

FAMILY CASSIDULINIDAE

GENUS PULVINULINELLA CUSHMAN, 1926

PULVINULINELLA PARVA CUSHMAN AND LAIMING, N. SP.

Plate 13, figures *5a-c*

Test small, unequally convex, dorsal side flattened except at the umbo, periphery acute, keeled, ventral side strongly convex; chambers

with about six making up the last-formed whorl, slightly inflated at the ventral side, of uniform shape, increasing very slightly in size as added; sutures somewhat indistinct on the dorsal side, more definite on the ventral side, slightly curved; wall smooth; aperture an elongate slit, nearly in the plane of coiling. Diameter 0.25 mm.; thickness 0.10-0.12 mm.

This is a very small species, but is fairly common in the section, and is easily distinguished from the following by its thin, keeled and unequally biconvex shape.

Holotype (Cushman Coll. No. 14,479) from the Miocene of Los Sauces Creek, Ventura County, California.

PULVINULINELLA SUBPERUVIANA CUSHMAN, VAR. MINUTA CUSHMAN AND LAIMING, N. VAR.

Plate 13, figs. 6*a-c*

Test nearly equally biconvex, periphery bluntly angular, not keeled, five or six chambers in the last-formed whorl, not inflated, increasing gradually in size as added, of uniform shape; sutures on the dorsal side, straight, strongly oblique, on the ventral side nearly radial, slightly curved, flush with the surface on both sides or very slightly depressed. Diameter 0.25 mm.; thickness 0.09 mm.

This is smaller than the Miocene *Pulvinulinella subperuviana*, and is distinct from the foregoing as is already noted.

Holotype of variety (Cushman Coll. No. 14,477) from the Miocene of Los Sauces Creek, Ventura County, California.

GENUS CASSIDULINA D'ORBIGNY, 1826

CASSIDULINA MARGARETA KARRER

Plate 13, figures 7*a-c*

Cassidulina margareta KARRER, *1877*, Abhandl. k. k. geol. Reichs., vol. 9, p. 386, pl. 16*b*, fig. 52.—CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 3, p. 56, pl. 9, figs. 29, 30.

Test small, somewhat compressed, periphery broadly rounded, about four pairs of chambers making up the last-formed whorl, diameter about twice the thickness in side view; chambers distinct but not inflated, broad; sutures fairly distinct, not depressed; wall smooth; aperture comparatively large, elongate. Length 0.30 mm.; breadth 0.25 mm.; thickness 0.15 mm.

The specimens from the Miocene of Los Sauces Creek seem to be identical with that described by Karrer from the Miocene of Austria. It is a very small species, but in the section is very constant in its character.

FAMILY CHILOSTOMELLIDAE

GENUS PULLENIA PARKER AND JONES, 1862

PULLENIA SALISBURYI R. E. AND K. C. STEWART

Plate 14, figures 2*a*, *b*

Pullenia salisburyi R. E. AND K. C. STEWART, *1930*, Jour. Pal., vol. 4, p. 72, pl. 8, figs. 2*a*, *b*.—CUSHMAN AND MOYER, *1930*, Contr. Cushman Lab. Foram. Res., vol. 6, p. 61, pl. 8, figs. 13*a*, *b*.

Test equally biconvex, compressed, periphery rounded; chambers distinct, slightly inflated, usually six in the last-formed coil; sutures slightly depressed, slightly curved; wall smooth, finely perforate; aperture a long narrow slit at the base of the apertural face with a slight lip above the opening. Length 0.50 mm.; breadth 0.45 mm.; thickness 0.20 mm.

Our specimens agree very closely with the types of these species described from the Pliocene of Ventura County, California. The species also occurs living off the California coast. Our record extends its range into the Miocene.

FAMILY GLOBIGERINIDAE

GENUS GLOBIGERINA D'ORBIGNY, 1826

GLOBIGERINA BULLOIDES D'ORBIGNY

Plate 14, figures 4*a-c*

The figure given here shows a specimen which seems very close to typical *Globigerina bulloides*. The chambers increase rather rapidly in size as added, the last three making up nearly the entire ventral surface.

GLOBIGERINA CONGLOMERATA SCHWAGER

Plate 14, figures 5*a-c*

In addition to the above species there is a second in which the chambers increase in size much less rapidly, and four or more chambers make up the last-formed whorl. The aperture also is smaller, the surface somewhat more coarse, cancellate, and the general characters are those of Schwager's species to which it is referred.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA GLABRATA Cushman

Plate 14, figures 1*a-c*

Anomalina glabrata Cushman, *1924*, Carnegie Inst., Washington, Publ. 342, p. 39, pl. 12, figs. 5-7.

Test free, biconvex, compressed, periphery broadly rounded, all chambers visible from the dorsal side, only those of the last-formed coil from the ventral side, which is umbilicate; eight or nine chambers in the last-formed coil; wall very smooth and polished, very finely punctate; sutures very distinct, but only very slightly depressed; aperture a curved opening at the base near the periphery and ventral angle of the last-formed chamber. Length 0.40 mm.; breadth 0.30-0.35 mm.; thickness 0.15-0.18 mm.

This species was described originally from Recent material from Samoa. The Miocene material from Los Sauces Creek agrees very closely with the types.

Explanation of Plate 14

Figs. 1 *a-c*—*Anomalina glabrata* Cushman. × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

2 *a, b*—*Pullenia salisburyi* R. E. and K. C. Stewart. × 70. *a* side view; *b*, peripheral view.

3 *a-c*—*Cancris sagra* (d'Orbigny). × 40. *a* dorsal view; *b*, ventral view; *c*, peripheral view.

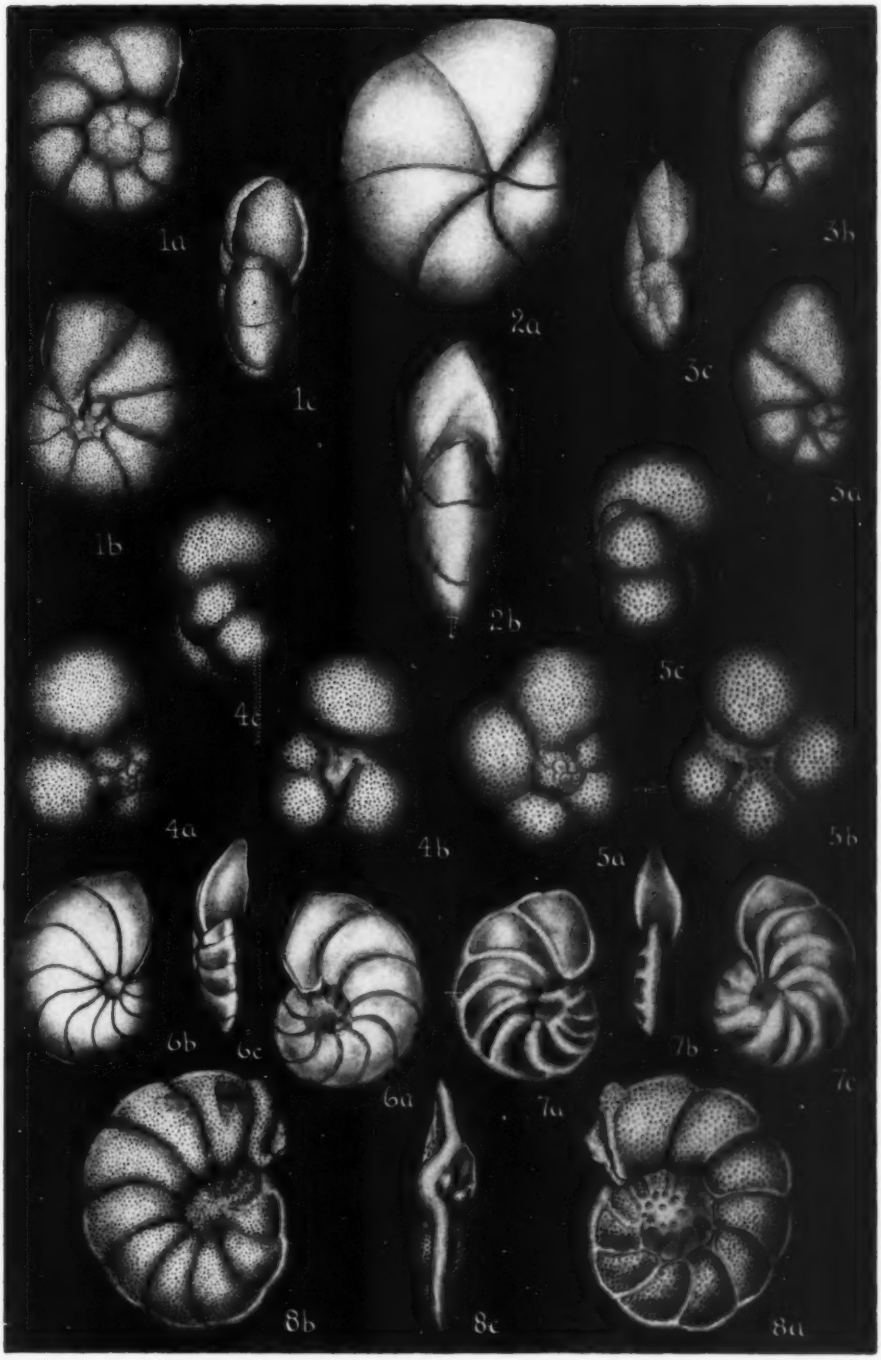
4 *a-c*—*Globigerina bulloides* d'Orbigny. × 70. *a* dorsal view; *b*, ventral view; *c*, peripheral view.

5 *a-c*—*Globigerina conglomerata* Schwager. × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

6 *a-c*—*Cibicides americanus* (Cushman). × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

7 *a-c*—*Cibicides americanus* (Cushman), var. *crassiseptus* Cushman and Laiming, n. var. × 70. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.

8 *a-c*—*Cibicides floridanus* (Cushman). × 40. *a*, dorsal view; *b*, ventral view; *c*, peripheral view.



Cushman and Laiming, Miocene Foraminifera

GENUS CIBICIDES MONTFORT, 1808

CIBICIDES AMERICANUS (CUSHMAN)

Plate 14, figures 6*a-c*

Truncatulina americana CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1.
Cibicides americanus HOWE, *1928*, Jour. Pal., vol. 2, p. 174.—CUSHMAN, *1930*, Fla. State Geol. Survey, Bull. 4, p. 61, pl. 12, figs. 5*a-c*.—COLE AND GILLESPIE, *1930*, Bull. Am. Pal., vol. 15, no. 57*b*, p. 14, pl. 4, fig. 4.

Test plano-convex, dorsal side nearly flat, ventral side slightly convex, periphery subacute; chambers numerous, eight to ten in the adult whorl, rather rapidly increasing in size; sutures distinct, slightly limbate on the dorsal side especially in the earlier chambers, depressed on the ventral side; wall smooth, finely perforate; aperture peripheral and extending onto the dorsal side, with a slight lip. Length 0.40 mm.; breadth 0.30 mm.; thickness 0.10 mm.

This species known from the Tertiary of various parts of America occurs in typical form in the Miocene of Los Sauces Creek.

CIBICIDES AMERICANUS (CUSHMAN), VAR. CRASSISEPTUS CUSHMAN AND LAIMING, N. VAR.

Plate 14, figures 7*a-c*

Variety differing from the typical in the very strongly limbate sutures which are thickened and raised on both sides fusing at the aperture to form a blunt keel. Length 0.35 mm.; breadth 0.30 mm.; thickness 0.10 mm.

This variety is very distinctive in the greatly developed ornamentation, and has a definite place in the section.

Holotype of variety (Cushman Coll. No. 14,487) from the Miocene of Los Sauces Creek, Ventura County, California.

CIBICIDES FLORIDANUS (CUSHMAN)

Plate 14, figures 8*a-c*

Truncatulina floridana CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 62, pl. 19, fig. 2.
Truncatulina lobatula (WALKER AND JACOB), var. *ornata* CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 61, pl. 18, figs. 1, 2.
Cibicides floridana CUSHMAN, *1930*, Fla. State Geol. Survey, Bull. 4, p. 61, pl. 12, figs. 3*a-c*.

Test trochoid, biconvex, dorsal side less convex than the ventral, periphery acute, keeled; chambers numerous, ten to twelve in the adult whorl; sutures distinct, limbate and raised on the ventral side, fused at the center into an umbonal mass; wall coarsely perforate; aperture ex-

tending along the dorsal side of the chamber margin. Diameter 0.90 mm.; thickness 0.20 mm.

This species which was originally described from the Miocene of Florida occurs in typical form in the Los Sauces Creek Miocene. It also occurs as a Recent species off the Florida coast. Typically the sutures are raised and very distinctly limbate, but occasionally specimens are found both in Recent and fossil material where the ornamentation is much reduced, and the later sutures on the dorsal side are depressed and not limbate. In the Los Sauces Creek section such a form occurs with a rather definite range in the lower member of the section, while the typical form has a much higher range in the section.

JOURNAL OF PALEONTOLOGY, VOL. 5, NO. 2, PP. 121-126, PLS. 15-17, 1 TEXT FIG., JUNE, 1931

THE GENUS *FAGESIA* IN THE UPPER CRETACEOUS OF THE PACIFIC COAST

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ABSTRACT

The genus *Fagesia*, a last survival of the *Olcostephanus* stock of cephalopoda, has not hitherto been reported from the Upper Cretaceous of North America north of the Mexican boundary. Its occurrence in the Turonian strata of South America had been known, but it was not until 1920 that it was discovered in contemporaneous beds in north-central Mexico. It has now been recognized in similar strata in other countries, and its appearance in the Upper Cretaceous of the Pacific Coast should cause no surprise. In a recent study of the Chico group of the West Coast Cretaceous three distinct species have come to light, and it is not unlikely that others will be found, not only here, but in the Upper Cretaceous of the Rocky Mountains, when sufficient search for them has been made. The genus is usually regarded as an index of the Turonian stage, wherever found. All of the West Coast species occur in this stage, as determined by their associated species, and by others found above and below their horizons.

Among the new forms of cephalopods that have come to light in a recent study of the Chico group of the California and Oregon Cretaceous, there are three species of the genus *Fagesia*, as it was originally defined by Pervinquière.

Although the genus has not been recorded before from the west coast, its discovery here should occasion no surprise, since various species of it occur in contemporaneous beds in southern India, and it now appears to be almost world-wide in its distribution, appearing in the upper Cretaceous of many countries in Asia, Africa, America, and Europe.

In 1898 Kossmat[1] described, under the name of *Olcostephanus superstes*, an Indian ammonite, believing that he had discovered a lower Cretaceous genus represented in upper Cretaceous strata, for which he expressed much interest and surprise.

Some years later the same, or a nearly related form, was discovered in upper Cretaceous beds in Tunis, north Africa, which was shown by Pervinquière to belong, not to the genus *Olcostephanus*, but to a distinct type, for which he proposed the name *Fagesia*, making Kossmat's species the genotype.[2] Both forms occur in strata of Turonian age,

[1]Kossmat, F., Sudind. Kreidef. II, 1898, p. 133, pl. 6.

[2]Pervinquière, L., Études de Pal. Tunis., Paris, 1907, p. 319.

which in Tunis furnish one or two other nearly related species. Pervinquière placed all of these in the same genus, and showed that they have near relatives in similar beds in Europe. He believed, as others do, that the group had its origin in the same stock as certain forms of *Acanthoceras* found in Turonian beds throughout the Mediterranean region.

Fagesia has been recognized in the upper Cretaceous strata of Peru, Colombia, Venezuela and Mexico. E. Böse described two species of *Fagesia* from north-central Mexico,[1] and as the record now stands this is its northernmost limit in the western hemisphere.

The many analogies that have been recognized in the faunas of the upper Cretaceous of southern India and of the Pacific coast of the United States and Canada leads one to expect that representatives of the genus will be found farther north. And as similar analogies exist in the later Cretaceous of the Andean region, Mexico and the western interior of North America, it is likely that others of the genus will be found in the upper Cretaceous of the Rocky Mountains, when sufficiently explored.

Most of the hitherto known species of the genus, not more than 10 in number, have been regarded as strictly Turonian in age, the Mexican species, according to Böse, coming from the lowermost beds (Salmurian) of this stage; other species range higher.

On the following pages are described three distinct species of *Fagesia* found in the middle Chico beds of California and Oregon.

At least one of these species, the larger and more common one, represents a middle Turonian horizon, while another comes from a lower Turonian (? Salmurian) horizon, as determined by associated species, and also by diagnostic forms found in contiguous beds a little above and below; the third form is from upper Turonian beds.

The holotypes of all these species, together with the associated forms from the same beds, are in the collections of the California Academy of Sciences, San Francisco.

[1]Böse, E., Univ. Texas Bull. No. 1856, 1920, pp. 211, 212, pls. 12 and 14.

EXPLANATION OF PLATE 15

FIG. 1—*Fagesia californica* Anderson, n. sp., side view of holotype No. 5496 (C. A. S. type coll.), showing the somewhat weathered suture lines. Diameter, 250 mm.

Anderson, *Fagesia* in the Upper Cretaceous

UNIV. OF MICH.

DESCRIPTION OF SPECIES

GENUS FAGESIA PERVINQUIÈRE

FAGESIA CALIFORNICA ANDERSON, N. SP.

Plate 15, figure 1; Plate 16, figures 1, 2; Plate 17, figure 1, Text figure 1

This shell attains a rather large size, being quite thick, with a broad, low cross-section of whorl, broadly rounded ventral surface, deep funnel-shaped umbilicus, strongly coronate on the borders, with stout nodes at short intervals; the transverse section which is at first somewhat elliptical or reniform, becomes later nearly as high as wide; the sutural line is simple. The ornamentation of the surface consists of 8 to 10 stout

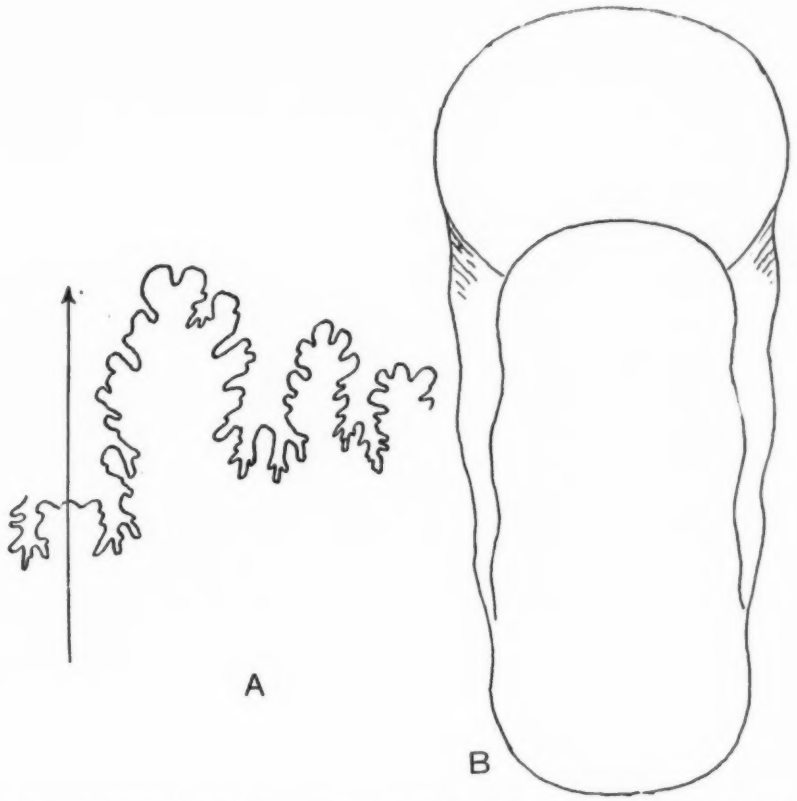

FIG. 1—A, Suture line of *Fagesia californica* Anderson, n. sp. × 1. Paratype No. 4685, (C. A. S. type coll.). B, *Fagesia shastensis* Anderson, n. sp., outline sketch of the front view of holotype No. 4690 (C. A. S. type coll.), showing the lateral undulations characteristic of the species.

rounded tubercules (nodes), from which faint, rounded transverse ribs can be seen crossing the ventral zone singly or in pairs.

Three examples of this species were found in Hayes Gulch, near Gas Point, Shasta County, associated with numerous middle Chico species that indicate a middle Turonian horizon. Another example was found in Jackson County, Oregon, associated with *Prionotropis branneri*, *Pachydiscus ashlandicus*, *Schloenbachia knighteni* and *Inoceramus labiatus*. The largest example of this species, holotype No. 5496, obtained at the Shasta County locality, has a greater diameter of nearly 10 inches (250 mm.) and a width of whorl of four inches.

The smaller examples are less perfect, but show the sutural characters very clearly. This species bears some resemblance to *Fagesia superstes* (Kossmat), but is less distinctly costate, and has fewer lateral tubercles. The following measurements were obtained from the holotype:

Greatest diameter,	250 mm.,	(Ratios)
Width of umbilicus,	122 mm.,	.488;
Height of whorl,	72 mm.,	.288;
Width of whorl,	95 mm.,	.380.

FAGESIA SHASTENSIS ANDERSON, N. SP.
Plate 16, figure 2, Text figure 1

Shell of medium size, broadly umbilicate; section of whorl roundly reniform; umbilicus broader than in the preceding species, the whorls rounded, the outer one bearing about 12 low rounded nodules, which in the younger whorls give rise to broad or flattened ribs which incline forward; in its earlier stages the umbilicus is relatively narrow and somewhat coronate; in older whorls it becomes relatively broader, the nodules becoming mere rounded prominences that can hardly be called nodes or nodules. The suture line, only partly visible, conforms to the type exhibited in *Fagesia californica*. This shell somewhat resembles

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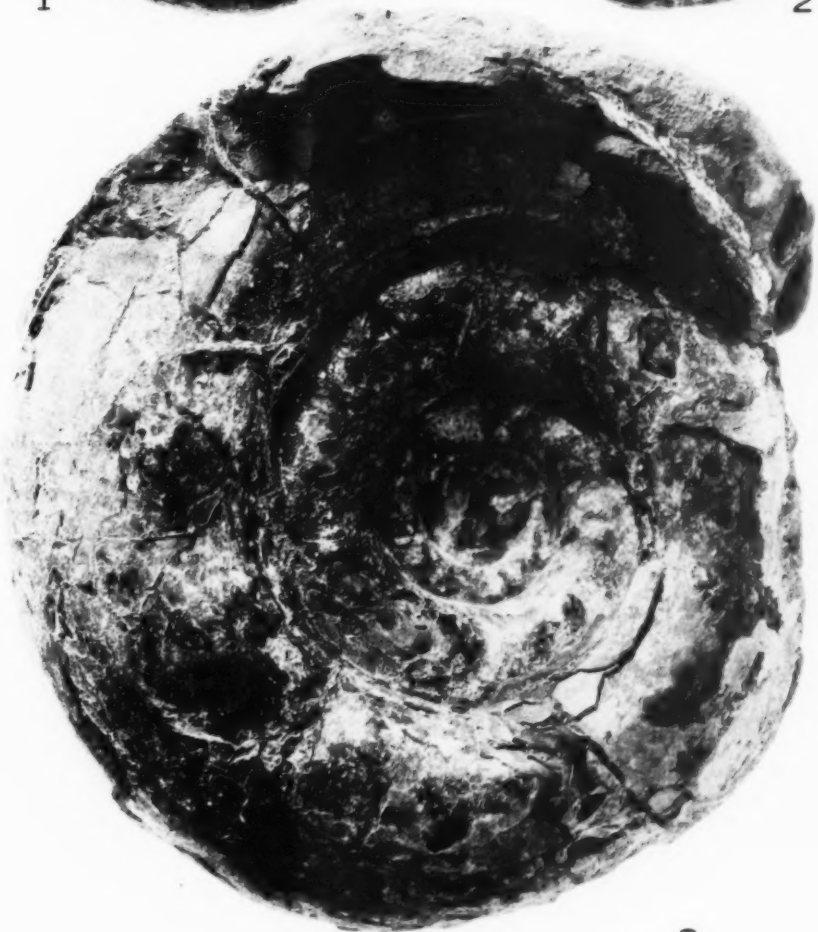
EXPLANATION OF PLATE 16

FIGS. 1, 2—*Fagesia californica* Anderson, n. sp., 1, side view of young example from southern Oregon, showing the characteristic lateral tubercules and funnel-form umbilicus; Paratype No. 4685 (C. A. S. type coll.). 2, front view of the example shown in Fig. 1 showing the cross-section of the same, the rounded periphery and tubercles.

3—*Fagesia shastensis* Anderson, n. sp., side view of holotype No. 4690 (C. A. S. type coll.), showing the undulating surface of the outer whorls, and the tubercles of the inner whorls. Suture lines not shown. Diameter, 137 mm.

1

2



3

Anderson, *Fagesia* in the Upper Cretaceous

Fagesia haarmanni Böse, but is less distinctly costate, has a somewhat higher whorl, and more rounded ventral zone showing only faint traces of ribs.

The holotype, No. 4690 (C. A. S. type coll.), gives the following approximate measurements:

Greatest diameter,	137 mm.,	(Ratios)
Width of umbilicus,	62 mm.,	.453;
Height of whorl,	42 mm.,	.300;
Width of whorl,	51 mm.,	.372.

This example was obtained from middle Chico beds on the Middle Fork of the Cottonwood Creek, some 6 miles southwest of Gas Point, Shasta County, midway between the basal conglomerates of the Chico group and the Foster ranch house. Its horizon is probably lower Turonian, since beneath it were beds with *Acanthoceras newboldi*, and above it beds with *Inoceramus labiatus*.

FAGESIA SISKIYOUENSIS ANDERSON, N. SP.
Plate 17, figures 2, 3

The shell of this species, as represented by the holotype, is of medium size, sub-spherical in form, with a deep funnel-form umbilicus, strongly coronate on the borders with numerous small rounded tubercles; cross-section reniform, or sub-semicircular; the sides narrow, set with about 16 nodes, from each of which branch off three, or rarely four rounded ribs, inclined somewhat forward, crossing the broadly rounded periphery; within the umbilicus heavier rounded single ribs descend the wall.

This species was obtained many years ago from the middle Chico beds near Henley, Siskiyou County, California, in a stratum a few hundred feet below one containing *Placenticeras pacificum* Smith, *P. californicus* Anderson, and *Pachydiscus henleyensis* Anderson. The horizon is regarded as uppermost Turonian.

The holotype, No. 4689 (C. A. S. type coll.), measures as follows:

Greatest diameter,	75 mm.,	(Ratios)
Width of umbilicus,	28 mm.,	.373;
Height of whorl,	30 mm.,	.400;
Width of whorl,	50 mm.,	.666.

EXPLANATION OF PLATE 17

FIGS. 1—*Fagesia californica* Anderson, n. sp., front view of holotype, No. 5496 (C. A. S. type coll.), showing the rounded periphery and the characteristic suture lines of the species.

2, 3—*Fagesia siskiyouensis* Anderson, n. sp. 2, front view of the holotype, No. 4689 (C. A. S. type coll.), showing the rounded periphery and the manner in which the costae cross the ventral zone. 3, side view of the holotype, showing the lateral nodes and costation characteristic of the species. Recovered from the fire of 1906. Diameter, 75 mm.

1

2

3

Anderson, *Fagesia* in the Upper Cretaceous

JOURNAL OF PALEONTOLOGY, VOL. 5, NO. 2, PP. 127-142, PLS. 18-19, 2 TEXT FIGS., JUNE, 1931

LEPIDECHINOIDES OLSSON, A GENUS OF DEVONIAN ECHINOIDS

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ABSTRACT

This paper consists of a discussion of the Devonian echinoid genus *Lepidechinoides* Olsson and a redescription of the type specimen and type species (*L. ithacensis* Olsson) of the genus. It also includes the description of a new species, *L. hunti*, of which seventeen specimens are known from the Hamilton (Skaneateles) shales of Unadilla Valley, New York. Another new species, *L. whitnalli*, from an unknown locality is also described. Data obtained from the type species and from the new species form the basis for an emended description of the genus. The paper is concluded with remarks on the anatomical structure and generic affinities of *Lepidechinoides*.

INTRODUCTION

During stratigraphic studies of the Hamilton group of Unadilla Valley, New York, the writer and C. B. Hunt collected several specimens of fossil sea-urchins. Echinoids are very rare from the Paleozoic formations of New York State. One species, *Koninckocidaris silurica* Jackson, is known from the Silurian, and two species, *Lepidocentrus drydenensis* (Vanuxem) and *Lepidechinoides ithacensis* Olsson, have been found in the Upper Devonian. Those here described as new are, therefore, the first to be reported from the Hamilton group.

In seeking the generic affinities of the new echinoids, it became apparent that the genus *Lepidechinoides* Olsson must be reinvestigated. The writer appealed to Dr. R. T. Jackson of the Museum of Comparative Zoölogy, Harvard University, for access to the specimen upon which Olsson based his genus. Dr. Jackson not only granted this request but also generously assisted the writer with many helpful suggestions and constructuve criticisms. The writer is deeply grateful for these favors.

The writer acknowledges here his indebtedness to Professor H. O. Whitnall of Colgate University for the loan of the choice specimen which now bears his name, and for placing at his disposal a grant from the Fairchild fund of the Colgate Museum to further the Hamilton field investigations which yielded these remarkable fossils. The holotype of *L. hunti* is in the U. S. National Museum (Cat. 84,218); all of the

other specimens are the property of Colgate University. Plastotypes have been deposited in Peabody Museum of Yale University and the United States National Museum, Washington, D. C.

OCCURRENCE OF THE HAMILTON SPECIES

The specimens of *L. hunti* described below were found in Palmer's Gully one and one-half miles northwest of West Edmeston village, Unadilla Valley, New York. It was Mr. Hunt who discovered a thin lens of calcareous sandstone abounding in the remains of a crinoid provisionally referred to *Gilbertsocrinus spinigerus* (Hall). In exploiting this layer for the crinoids the discovery of the echinoids was made. This lens is in thin-bedded, arenaceous shales at the top of the large falls near the head of the gully. The supporting ledge of the cascade is a calcareous sandstone abounding in "*Atrypa reticularis* (Linnaeus)," *Cornellites flabellus* (Conrad), *Pholidostrophia nacrea* (Hall), and *Stropheodonta* cf. *S. demissa* (Conrad), which forms a flat in the stream bottom. These calcareous, hard layers are followed by dark, thin-bedded arenaceous shale, twelve feet above the base of which the echinoids were found (approximately 1,465 feet above sea-level). These shales are in the Berwyn member of the Skaneateles formation.[1]

The echinoids occur both in the calcareo-arenaceous lens and in the arenaceous shale immediately beneath it. Specimens could not be extracted from the fresh rock because the calcareous plates are cemented to the matrix. The two specimens of *L. hunti* here described were found in the coarse shale at the lower contact with the lens. At that horizon the rock has been leached of its lime and the fossils are preserved as molds of the interior and exterior, preserving as impressions the structure of the test in considerable detail. The specimens found in the lens itself were practically worthless for study.

THE GENOTYPE

Errors in Original Description. The echinoids in question are referred to the genus *Lepidechinoides* Olsson[1] from the Ithaca beds of central New York. It will be necessary, however, before describing the new species, to inquire closely into the structure of this genus since it has been found that the original generic description is inaccurate in detail and is therefore quite misleading. Through the courtesy of Dr. R. T. Jackson, the writer was enabled to study the specimen upon which

[1]Am. Jour. Sci., (6), vol. 19, p. 212, 1930.

[2]Am. Jour. Sci., (5), vol. 33, p. 442, 1912.

Olsson based his genus. The writer was also permitted to photograph this specimen and the figures obtained are reproduced in this paper.

The chief error in Olsson's description is in the reversion of imbrication in the ambulacral and interambulacral columns as described, due to the incorrect orientation of the figure. The interambulacral plates imbricate adapically, not adorally as stated; the ambulacral plates imbricate adorally, not aborally as Olsson asserts. Olsson figures a "pore" piercing each ambulacral plate near the admedian suture on the extreme ventral surface. These so-called "pores" actually exist but should not have been interpreted as "pores" in the test of the living animal. The ambulacral pores of the test in an internal mold (pl. 19, fig. 3) are represented by vertical plugs. On the other hand, these pits, or gashes, between the plugs representing the ambulacral pores and the median suture represent molds of internal, adoral spinose processes on the ambulacral plates. Similar adoral internal ambulacral spinose processes, one to each plate, have been described by Jackson[1] in three species of *Hyattechinus*. He also described similar internal spinose processes in the recent *Eucidaris* and *Phyllacanthus*.[2]

In interpreting Paleozoic echinoids, it is important to bear in mind the exact nature of the preservation of the fossil which is under consideration, whether a mold of the interior or the exterior. Olsson's specimen is a mold of the interior, consequently all elevations on the inside of the living test, such as the internal spinose processes, will appear as pits or depressions on the specimen, and the fillings of the ambulacral pores will appear as protuberant plugs. Olsson also mentions that the adradial plates are "perforated near the ambulacral edge." A study of the original specimen shows these perforations in some members of this column of plates but they are not universal throughout the specimen. These perforations or pits appear to be due to injury to the specimen during fossilization and to have no relation whatever to the internal anatomy of the animal. With these points in mind, a description of the holotype can be presented.

LEPIDECHINOIDES ITHACENSIS Olsson
Plate 19, figures 1-3, Text figures 1A, 2B
Am. Jour. Sci., ser. 5, vol. 33, p. 442, 1912

The specimen is preserved as an internal mold, retaining nearly half the test; it includes the ventral and peristomal regions, and shows

[1]Phylogeny of Echini, Mem. Bost. Soc. Nat. Hist., vol. 7, 1912, pp. 292-299; Mus. Roy. d' Hist. Nat. de Belg., Mem. 38, 1929, p. 29.

[2]Phylogeny, Echini, Mem. Bost. Soc. Nat. Hist., vol. 7, 1912, p. 61.

parts of three ambulacral areas and portions of four interambulacra. The specimen is 27.5 mm. wide at its widest point which is about 9 mm. from the extreme ventral margin. This does not, however, correspond to the position of the ambitus. The height of the specimen is about 20 mm. The sides of the ambulacral columns are nearly parallel in the adapical portion of the column but taper slightly toward the ventral pole. An ambulacrum is 4.5 mm. wide at its widest point and about 3.3 mm. wide on the ventral surface. The ambulacral plates imbricate adorally and bevel under the adradial column. The ambulacra are composed of two columns of moderately low primary plates, the height of about four plates equalling the height of one adradial plate. Ambulacral plates immediately adjacent to a transverse adradial suture are expanded laterally but are not so expanded at the median suture. Each

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EXPLANATION OF PLATE 18

All figures unretouched

FIGS. 1-7—*Lepidechinoides hunti* Cooper, n. sp. Hamilton (Skaneateles), Palmer's Gully, West Edmeston, New York.

1—Wax impression taken from the internal mold of the holotype, × 2 (compare with fig. 3, this plate). It is thus a replica of the original test as seen from within. Adoral imbrication of ambulacral plates clear; lateral imbrication of interambulacral plates over ambulacral plates also clear (the ambulacral plates appear to lie on the adradial edges of the interambulacral column). Ambulacral plates opposite the sutures of the adradial plates flabelliform; ambulacral pores seen as pits, half pyramids of lantern seen adorally.

2—Wax impression taken from the internal mold of ambulacrum B of the holotype, × 4.5, seen from the inside (compare fig. 1, this plate). The fan-shaped ambulacral plates opposite sutures of adradial plates are clearly shown.

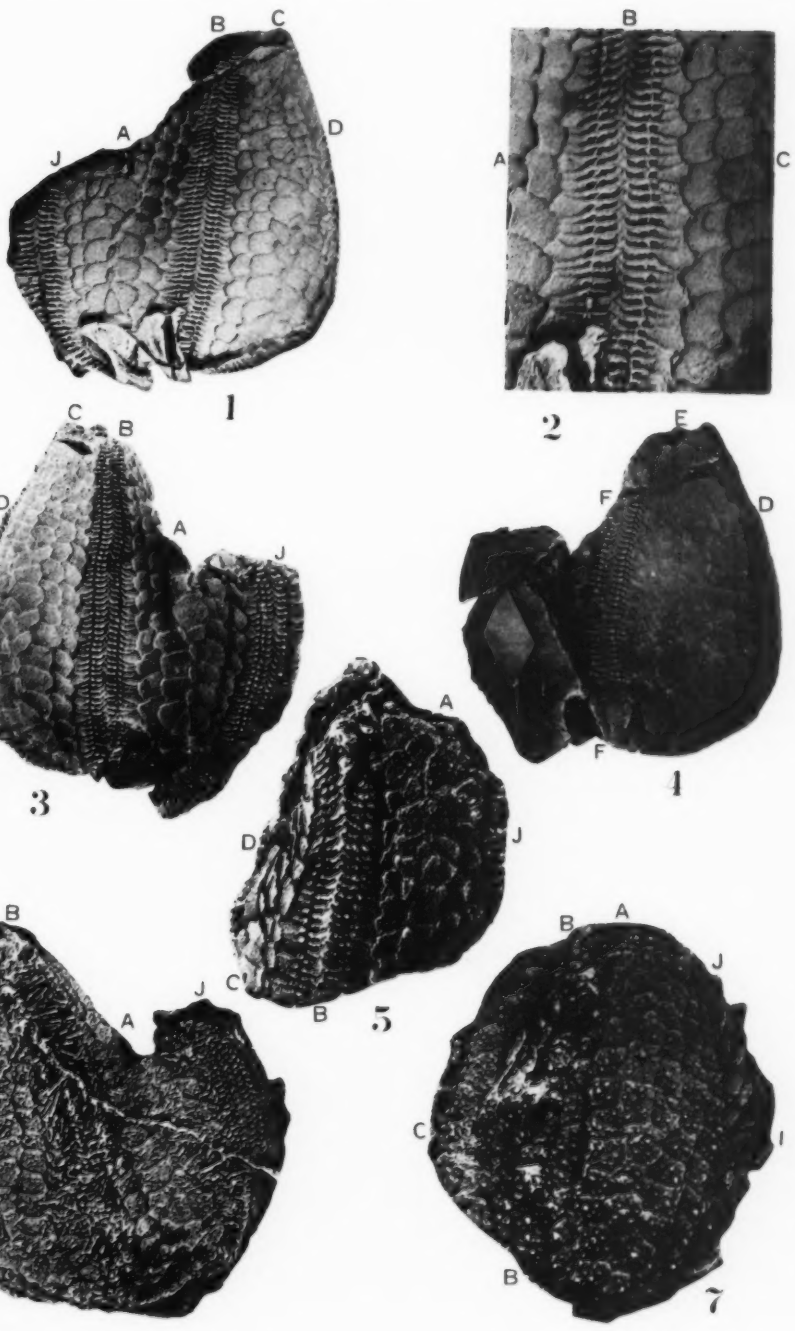
3—Internal mold of the holotype, × 2. Fan-shaped interambulacral plates opposite horizontal adradial suture well exhibited. In the interambulacra A and C column 5 is recorded as a row of narrow, lozenge-shaped impressions (compare fig. 1, this plate). Compare width of ambulacrum B in this figure with fig. 6 of this plate; these show the variation between the exterior and interior. At the apicad extremity of interambulacrum C, three plugs representing pores of a genital plate of unknown outline are visible. Compare text fig. 1A.

4—Internal mold of the holotype, × 2, showing ambulacra D and F and interambulacrum E. This view is the reverse side of fig. 3. An internal mold of two pyramids of the lantern can be seen at the ventral extremities of ambulacra D and F. Compare text fig. 2A.

5—Internal mold of the paratype, × 4.

6—Wax impression showing the exterior of the holotype, × 2. This specimen shows the strong adapical bevelling of the interambulacral plates and an abundance of small spines. Compare text fig. 1F.

7—Wax impression from the external mold of the paratype, × 4, showing a replica of the exterior. The strong adapical imbrication of interambulacral plates is clear. Compare text fig. 1B.



Cooper, Devonian Echinoids

fan-shaped plate is separated from the next by two unexpanded plates except ventrally where a single low plate intervenes between the flabelliform plates.

This lateral expansion of the ambulacral plates (text fig. 1A) opposite the horizontal adradial suture makes it difficult to define accurately the number of ambulacral plates opposite an adradial plate since the adambulacral suture bisects the flabelliform member of the ambulacrum. Therefore, in counting the ambulacral plates, the height of each adambulacral plate is considered to equal the height of two half-flabelliform plates (one adapical half and one adoral half) plus the heights of the intervening nonexpanded plates.

Ambulacral pores are represented by elevated plugs; the pore-pairs uniserial, generally oblique, with the outer pore higher than the inner pore as usual in Paleozoic echini. Pore-pairs are generally located approximately in the center of the plates, but it must be borne in mind that this is a mold of the interior and that the pore-pairs were probably situated nearer the interambulacra on the exterior of the test. In the extreme ventral portion of the area and for about 8 mm. from the mouth the impression of each ambulacral plate on the specimen bears a pit (pl. 19, fig. 1) located near the median suture and between it and the pore-pair. These pits, or gashes, represent the molds of the internal spinose processes (pl. 19, fig. 2) known before among Paleozoic sea-urchins only in *Hyattechinus* Jackson.

An interambulacrum measures 14 mm. in width, or three times the width of an ambulacrum. There are six columns of plates in an interambulacrum imbricating adapically and from the center laterally and over the ambulacra. The impression of the primordial interambulacral plate is small, irregular, sub-pentagonal. The impressions of the adradial plates show them to have been internally subrhombic in outline; the impression of the inner columns of plates shows them to have been internally sub-pentagonal or sub-hexagonal. The sixth or last column is introduced at the ninth row from the ventral border.

The peristome is small and appears to have been plated by ambulacrals only, as in *Hyattechinus* and other genera in the family Lepidocentridae. The mouth is small. Spines, as reported by Olsson, are secondaries, striated longitudinally and dilated at the base.

Occurrence. Portage beds. McGraw Quarry, Cornell University campus, Ithaca, New York. Museum of Comparative Zoölogy Catalogue No. 3,341.

NEW SPECIES

The generic diagnosis of *Lepidechinoides* will be made more comprehensive by a review of the structures preserved in the new species, some of which structures are not preserved in the specimen representing the genotype.

LEPIDECHINOIDES HUNTI COOPER, N. SP.
Plate 18, figures 1-7; text figures 1B,C,F and 2A

Holotype. There are 17 individuals of this species in the collection from Palmer's Gully, but only two of them preserve the structure in sufficient detail to permit description. Fortunately, each of these specimens is represented by both internal and external molds. The larger of the two specimens and the one selected as the holotype is described first. The holotype (pl. 18, figs. 3, 4, 6) consists of two specimens, an external and an internal mold. The external mold (pl. 18, fig. 6) is 25 mm. high and 22 mm. wide, preserving two ambulacral and two interambulacral areas. Ambulacrum B and interambulacrum C are nearly complete. The internal mold (pl. 18, figs. 3, 4) is 22 mm. high and 22 mm. wide, preserving portions of three interambulacral (areas B, C, D, and E are nearly complete) and four ambulacra.

Exterior. In the description of the exterior a wax cast of the external mold has been employed (pl. 18, fig. 6). The surface bears many spines which are concentrated chiefly in the ambulacra. The spines are all secondaries, the longest one observed measuring 2 mm. in length. They are striated longitudinally and are dilated at the base.

The ambulacrum is narrow, measuring about 3 mm. in width at the ambitus, or one-third the width of the interambulacrum. The ambulacrum is composed of primary plates, about four equalling the height of one adradial plate. Pore-pairs are uniserial, surrounded by peripodia, located nearest to the adradial margins. The pore-pairs are oblique to the horizontal, the outer pore slightly higher than the inner pore. Each ambulacrum bears one or more spines. A large tubercle—large in its relation to its fellows—is borne on each plate between the pore-pair and the perradial suture. The ambulacral plates bevel strongly adorally and laterally under the adradial column.

The interambulacrum is 9 mm. wide at the ambitus or three times the width of the ambulacral area. It is composed of six columns of high plates imbricating adapically and from the center laterally over the ambulacral plates. The adradial columns appear to be composed of rhombic plates, but in columns 3, 4, 5, and 6 the plates are clearly hex-

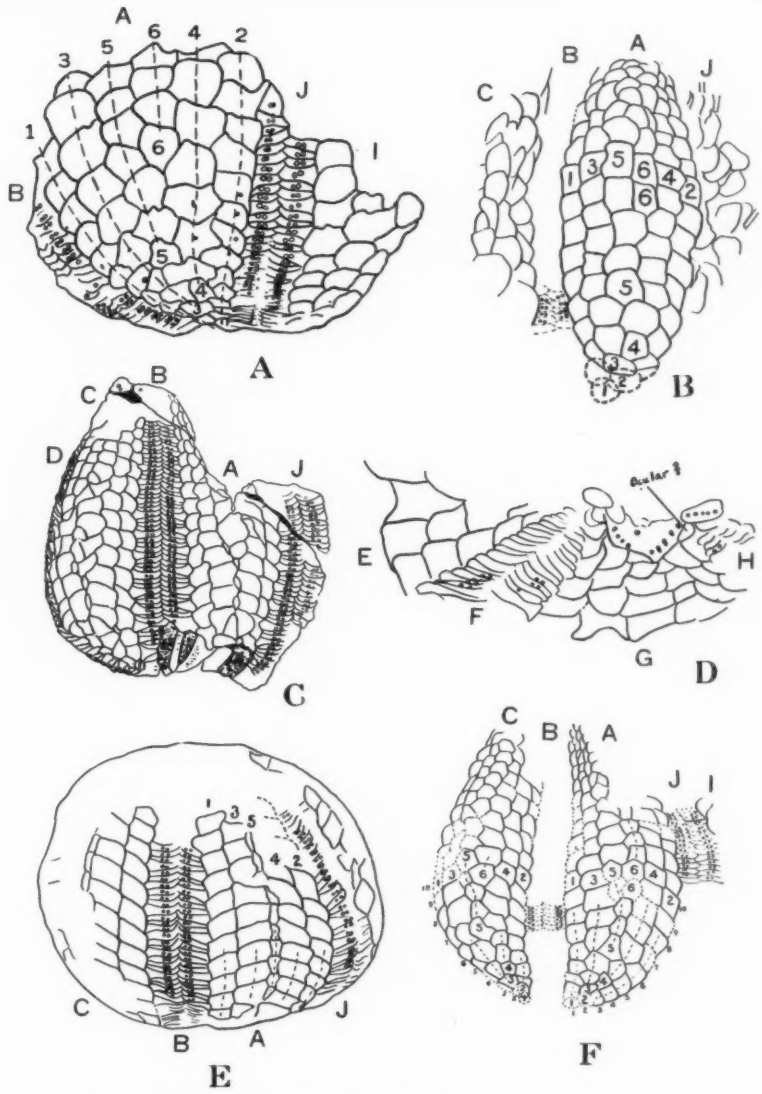


FIG. 1 A—*Ledpidechinoides ithacensis* Olsson, lateral view, ± × 2 (compare plate 19, fig. 3).

B, C, F—*Lepidechinoides hunti* Cooper, n. sp. B, Exterior of the paratype, × 3.5 (compare plate 18, fig. 7). C, Internal mold of the holotype, × 1.75 (compare plate 18, fig. 3). F, External view of the holotype, × 1.75 (compare plate 18, fig. 6).

D, E—*Lepidechinoides whitnalli* Cooper, n. sp. D, Camera lucida sketch of interambulacrum A as seen from the inside, showing the overlying genital plate (compare plate 19, fig. 4). E, Internal mold of the holotype, side view, ± × 1.25 (compare plate 19, fig. 6).

agonal in outline. Each inner ambulacral plate has many small tubercles up to ten in number. In the development of the columns, the sixth column appears in the ninth row and the fifth column originates in the sixth row.

Interior. (pl. 18, figs. 3, 4). The ambulacra are 3.7-4.5 mm. wide, depending upon whether the measurement is made between the projecting margins of the adambulacral plates or the reentrants between them. Area B tapers adapically from 4.5 mm. in width to 2.5 mm. The areas also taper slightly toward the oral pole but the amount could not be measured. The ambulacral pores are preserved as elevated plugs, as it is an internal mold; pore-pairs are situated approximately in the center of the plates, usually not obliquely. Ambulacral plates are low, the height of three to four plates equalling the height of an adambulacral plate (pl. 18, figs. 1, 3). Each ambulacral plate opposite the horizontal adradial suture is fan-shaped as in *Lovenechinus* Jackson and *Melonechinus* Meek and Worthen. This "fanning" of the ambulacral plates is a feature characteristic of the interior only. Between each fan-shaped plate and the next there are two or three lower plates, three throughout most of the area, and especially near the center of the test, but nearer the apex there are only two plates between the fan-shaped plates and in the apical portion the fan-shaped character is less pronounced. On the extreme ventral surface each ambulacral plate impression bears a pit, or gash, which is the mold of an internal spinose process situated near the perradial suture. These spinose processes extended adapically for about 4 mm. from the peristome. The interambulacral area is 7 mm. wide, less than twice the width of the ambulacrum. It preserves the impressions of six columns of plates. The imbrication is so strong adapically that the fifth column in the vicinity of the ambitus is recorded on the internal mold as small, lozenge-shaped impressions only (pl. 18, fig. 3). The sixth column on the inside is nearly obliterated so that only five columns of plates can be counted about 5 mm. below the apex of the specimen. But on the external mold in the corresponding position, six columns of plates are clearly visible.

A mold of the lantern (pl. 18, fig. 3; text figure 2A) is preserved at the ventral extremities of areas E and F. It is inclined and the foramen magnum is unusually shallow.

Paratype. The specimens comprising the paratype (pl. 18, figs. 5, 7) are an external mold and an internal mold. The external mold is 12 mm. high and 10.5 mm. wide, preserving one interambulacral area and one ambulacral area. The internal mold is 11 mm. high and 8 mm. wide

preserving portions of three ambulacral areas and two interambulacral areas. The specimens are considered as representing a youthful individual of *L. hunti*.

Exterior. (Pl. 18, fig. 7; text figure 1B). Interambulacrum A is well preserved, showing all parts except the genital plate and the primordial interambulacral plate. It is 5 mm. wide and has six columns of plates imbricating strongly adapically and from the center laterally and over the ambulacra. The plates are roughly hexagonal in outline except the adradials which are subpentagonal in outline. The primordial interambulacral plate is not in place but the three adoral plates are considered as representing the third row. In the fourth and fifth rows there are four plates. Column five appears in the sixth row and column six is seen first in the ninth row. The plates bear as many as ten spines. The longest spine noticed, associated with this test, is 1.25 mm. in length.

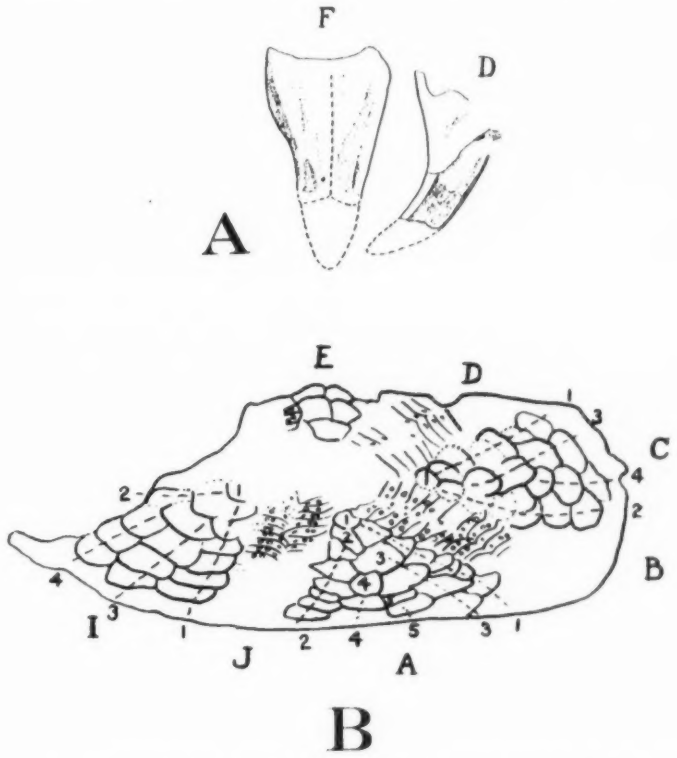


FIG. 2 A—*Lepidechinoides hunti* Cooper, n. sp. Reconstruction of two pyramids of the lantern (compare plate 18, fig. 4).

B—*Lepidechinoides ithacensis* Olsson, oral view, ± × 3 (compare plate 19, fig. 1).

The ambulacral area is poorly preserved. It is 1.5 mm. wide, and composed of primary plates imbricating adorally. About four plates equal one adradial plate in height.

Interior. (Pl. 18, fig. 5). The internal mold is too badly preserved to yield any further information concerning the interambulacrum. At its widest point the ambulacrum measures 3 mm. The plates are low, four equalling the height of an adradial plate. The plates opposite the transverse adradial sutures are expanded laterally as in *L. ithacensis*.

The species is named in honor of Charles B. Hunt who helped so materially in its discovery.

Occurrence and geological horizon. In the Skaneateles (Berwyn) shales of the Hamilton group, Palmer's Gully, 1.5 miles northwest of West Edmeston, New York.

EXPLANATION OF PLATE 19

All figures unretouched

FIGS. 1-3—*Lepidechinoides ithacensis* Olsson. Portage, McGraw quarry, Cornell University campus, Ithaca, New York. Museum of Comparative Zoölogy, No. 3,341.

1—Internal mold of the holotype, oral view, × 2. Ambulacral pores are represented by vertical fillings or plugs, and the internal spinose processes on the ambulacrum are represented by pits or gashes, seen especially well in areas J, B and D. The primordial ambulacral plate is in place in areas A and C. Compare text figure 2B.

2—Wax impression of portions of ambulacra J and B, showing spinose processes, × 2. This figure illustrates a replica of the interior of the original test. Ambulacral pores are seen as pits and the internal spinose processes as protuberances.

3—Internal mold of the holotype seen from the side, × 2. Compare text fig. 1A.

4-8—*Lepidechinoides whitnalli* Cooper, n. sp. Locality and horizon unknown but probably from New York Devonian.

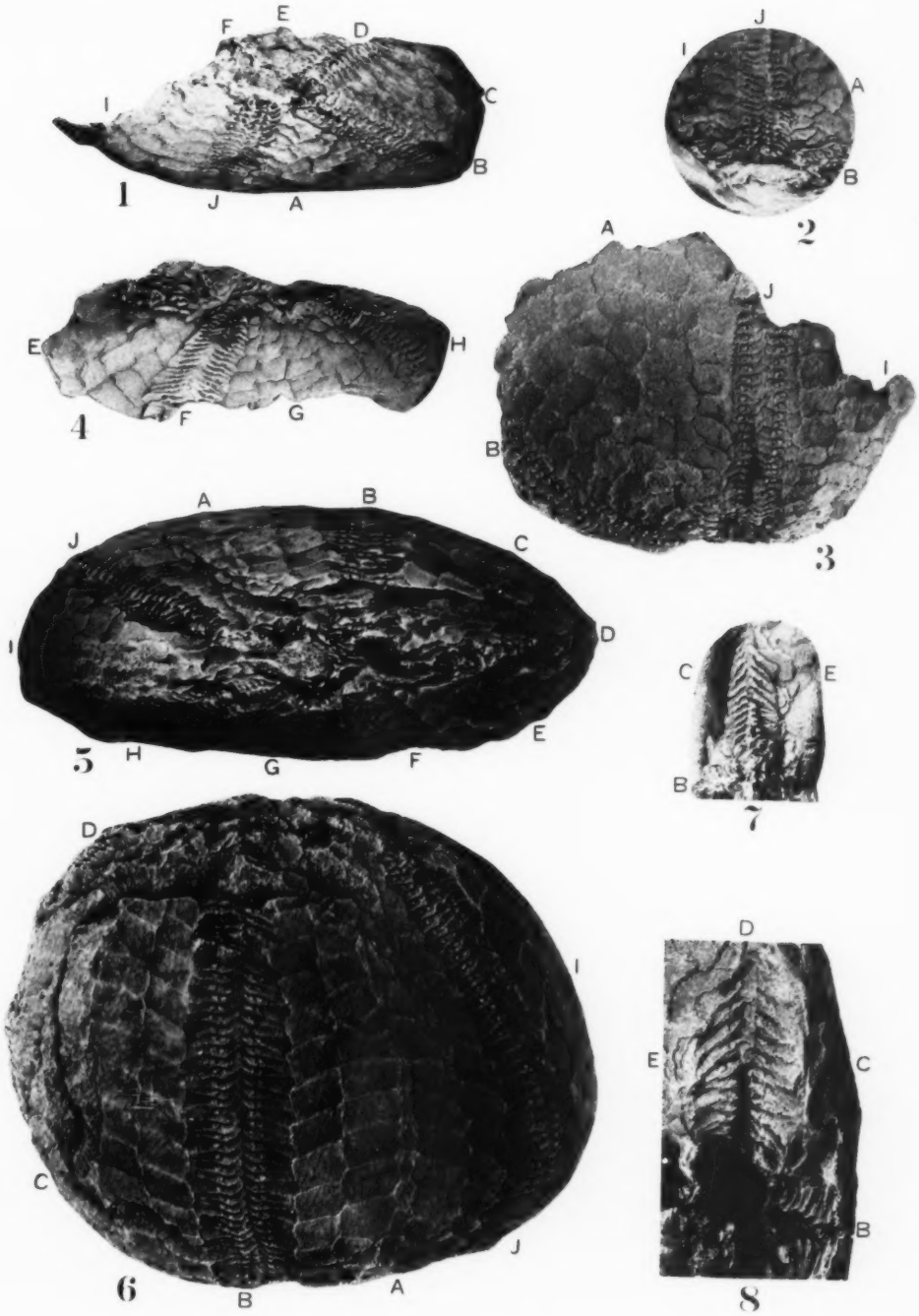
4—Wax impression of interambulacrum G, × 2. Shows a replica of the interior of the test; bevelling of ambulacral and interambulacral plates clear; genital plate with pores as pits shows clearly in area G. Compare text fig. 1D.

5—Apical view of the holotype, × 2, showing all of the areas. A nearly complete genital plate overlies area G, and portions of others are to be seen at the top of areas A and I. Genital pores appear as vertical plugs.

6—Lateral view of the holotype, × 2. Ambulacra with fan-shaped plates opposite adradial sutures; ambulacral pores represented by vertical plugs near admedian suture; five columns of plates show clearly in interambulacrum A; fifth column seen as narrow lozenge-shaped plates. Compare text fig. 1E.

7—Wax impression of a portion of ambulacrum D, × 3, near the mouth showing internal spinose processes.

8—Oral view showing molds of the internal spinose processes which appear as holes near the mid-line of the ambulacrum.



Cooper, Devonian Echinoids

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It will be observed from the foregoing that there is considerable difference between the exterior and the interior of the test. On account of the lateral imbrication of the adradials over the ambulacral areas, the ambulacra are wider on the inside of the test than they are on the outside. Consequently, also, the interambulacra are considerably narrower on the inside than on the outside of the test. Furthermore, the lateral expansion of the ambulacral plates opposite the horizontal adradial suture is a feature of the inside of the test not seen on the exterior.

In comparing *L. ithacensis* with *L. hunti*, it is possible to make direct comparison between the internal molds only. Important specific differences between the two species are seen in the greater proportionate width of the ambulacra as compared to the interambulacra. The ambulacrum of *L. ithacensis* is only one-third the width of the interambulacrum, but the ambulacrum of *L. hunti* is more than half the width of the interambulacrum. In *L. ithacensis* two to three ambulacral plates equal the height of an adradial plate whereas there are usually four equal to the height of an adradial plate in *L. hunti*. Again, in *L. ithacensis* the maximum number of plates between the flabelliform ambulacrals is two, but there are usually three plates similarly situated in *L. hunti*. In the latter species, the internal spinose processes continue from the base adapically for 4 mm. only but in *L. ithacensis* they extend for twice this distance. In the interambulacrum of *L. ithacensis* the imbrication is not so strong as in *L. hunti* where column five is so greatly reduced on the internal impression.

LEPIDECHINOIDES WHITNALLI Cooper, n. sp.

Plate 19, figures 4-8; text figures 1D, E

Holotype. The single known specimen is an internal mold 38 mm. wide and 31 mm. high, slightly crushed. It preserves portions of all the ambulacra, areas B and J being nearly complete; portions of all the interambulacra are preserved also, areas A and C being nearly complete. Ambulacral area B is 7 mm. wide at the ambitus and tapers toward each pole. The ambulacrum is composed of two columns of primary plates, imbricating adorally and under the adradial columns. Porepairs uniserial, placed nearest the perradial suture. Normally, four ambulacral plates equal the height of one adradial plate but three equalling the height of one adradial plate occurs sporadically in the areas. Ambulacral plates opposite each transverse adradial suture are expanded laterally and fan-shaped. Ventral adradial sutures are expanded laterally and fan-shaped. Ventral ambulacral plate impres-

sions have deep pits situated between the perradial suture and the pore-pair, representing molds of internal spinose processes (pl. 19, figs. 7, 8). These can be seen for a distance of about 10 mm. adapically from the mouth. The peristome is covered by ambulacral plates only.

The interambulacrum is twice the width (14 mm.) of an ambulacrum at the ambitus, composed of five columns of plates imbricating adapically and from the center outward and over the ambulacral areas. The internal impressions of the plates are rhombic in outline, wider than high. On the internal mold, column five appears as a line of narrow, elongate impressions, so strong is the imbrication.

Some elements of the apical system are preserved. A genital plate overlies interambulacrum A, and two other genitals less distinctly seen, overlie interambulacra E and I. They are large and subcrescentic in outline. Nine pores (preserved as plugs) may be counted. Since there are five pores on one side of the plate and four on the other, where it is injured slightly, it is quite possible that the genital plate was provided with ten pores. The oculars are scarcely visible, small, insert.

This echinoid differs from *L. hunti* in size, proportionately narrower ambulacral areas in relation to the interambulacral areas on the inside of the test, differently shaped interambulacral plates, and a lesser number of interambulacral columns. Furthermore, the internal adoral spinose processes are continued adapically for a greater distance, and the pore-pairs are closer to the perradial suture than in *L. hunti*. The same features distinguish *L. whitnalli* from *L. ithacensis*, there being practically no characters in common.

The locality and stratigraphic horizon of *L. whitnalli* are unknown. The specimen was found at Colgate University among a miscellaneous lot of New York fossils included in a collection of Herkimer quartz crystals and other minerals. The collection was given by a Mr. Vosburg of Utica and Little Falls, New York, to Colgate University from which it was borrowed by the writer. All of the fossils and nearly all the specimens in the collection were from New York State; it is therefore reasonable to suppose that this specimen, too, was derived from the rocks of the same state.

The specimen was broken along a crack in the hope of finding diagnostic fossils within by which to determine the age of the species. Unfortunately none were found. The lithology of the interior is a fine arenaceous shale or siltstone similar to that of *L. ithacensis* and a kind common in the Hamilton and Upper Devonian of central and eastern

New York. It is reasonable to assume a Devonian age for the species because of its close generic affinities with *L. hunti* and *L. ithacensis*.

EMENDED GENERIC DESCRIPTION OF *LEPIDECHINOIDES*

It will be noticed that *L. ithacensis* and each of the two other species described have certain anatomical features in common, as follows:

1. Imbricating ambulacral and interambulacral plates, the ambulacral plates imbricating adorally and the interambulacral plates imbricating adapically and from the center laterally and over the ambulacral areas.

2. Two columns of moderately low, primary ambulacral plates and five or six columns of thin, subhexagonal or rhombic plates in the interambulacrum.

3. Ambulacral plates opposite the horizontal adradial sutures expanded laterally and fan-shaped.

4. Internal spinose processes on the ventral portion of the ambulacrum.

With these common anatomical features as the chief generic characters, combined with data not common to each of the species, it is possible to compose an emended description of the genus as follows:

Lepidechinoides Olsson, emended. Seen from the exterior, the test is spheroidal, ambulacral areas narrow, one-third to one-half the width of an interambulacrum, composed of two columns of low primary plates imbricating adorally and under the adradial columns. The height of two to four ambulacral plates equals the height of an adradial plate. Pore-pairs uniserial, oblique, surrounded by peripodia, situated near the adradial margin. Ambulacral plates with secondary spines only.

Viewed from the interior, the ambulacral plates are of two kinds: (1) those opposite the transverse adradial sutures, which are expanded laterally and fan-shaped, but not expanded toward the middle of the area; (2) the intervening plates which are low throughout. The pore-pairs are located near the center of the plates, or nearer the median suture. Ventrally, each ambulacral plate bears an internal spinose process situated between the pore-pair and the median suture.

Externally, the interambulacra are two or three times the width of the ambulacra at the ambitus. They have five or six columns of plates imbricating adapically and from the center outward over the ambulacral areas. The plates are rhomboidal, rounded pentagonal, or hexagonal in outline. Secondary spines and tubercles, up to ten in number, are borne

on the plates. Primordial interambulacral plate in place, as it is typically in the Lepidocentridae.

Apical system probably with oculars insert, genitals large with many pores, probably up to ten in *L. whitnalli*. Lantern inclined, foramen magnum exceedingly shallow; peristome plated by ambulacral plates only.

ANATOMICAL DISCUSSION

Lepidechinoides as emended shows two unusual anatomical features, the presence of fan-shaped ambulacral plates opposite the horizontal adradial sutures on the interior of the test (pl. 18, figs. 1-3, 5; pl. 19, figs. 3, 6) and internal spinose processes on the ambulacral plates of the ventral portion of the area (pl. 19, figs. 1, 2, 7, 8).

1. Fan-shaped ambulacral plates opposite the horizontal adradial sutures are a feature of the inside of the test as shown by Jackson[1] in some genera of the family Palaeechinidae. This feature occurs in *Lovenechinus* Jackson and *Melonechinus* Meek and Worthen. It cannot, however, be considered as more than a generic character since it is not known in other members of the same family such as *Palaeechinus* M'Coy, or *Maccoya* Pomel.

The members of the Palaeechinidae all have tests in which there is no imbrication of the plates although along the adradial suture the ambulacral plates bevel over the interambulacral plates. This is just the reverse of the condition in completely imbricate types where interambulacral plates bevel over the ambulacral. The first to report this fanning of the ambulacrals opposite the horizontal adradial suture in imbricate sea-urchins were Hawkins and Hampton[2] in the much discussed species *Palaeodiscus ferox* Salter. The authors considered that the "... . advantage of this arrangement to imbrication is manifest." The adjustment is not so manifest when it is considered that this feature has not been reported in the tests of other imbricating sea-urchins and that, previous to its discovery in *Palaeodiscus* by Hawkins and Hampton it was recorded by Jackson in certain genera of Paleozoic sea-urchins of the family Palaeechinidae only. Jackson offers no explanation for the phenomenon and with our present knowledge of Paleozoic echini none seems to offer itself readily. It is possible, however, that the phenomenon represents the incipient development of occlusion of plates which reaches

[1]Mem. Bost. Soc. Nat. Hist., vol. 7, p. 339, 1912.

[2]Quart. Jour. Geol. Soc. London, vol. 83, pp. 594, 595, 1927.

its maximum development in the Lepidesthidae. The presence of these fan-shaped plates in association with occluded plates in *Lovenechinus* and *Melonechinus* is at least suggestive.

2. Internal spinose processes. These are rather elongate spines, elliptical at the base, located on the inner surface of the ambulacral plates of the ventral portion of the test. They are situated between the pore-pairs and the median suture. Such internal spinose processes have been observed before only in *Hyattechinus beecheri* Jackson, *H. elegans* Jackson, and *H. rarispinus* (Hall) among Paleozoic echini. Among recent sea-urchins such spinose processes have been described by Jackson in *Phyllacanthus baculosa* (Lamarck) and *Eucidaris tribuloides* (Lamarck).

GENERIC AFFINITIES

Lepidechinoides is most closely allied by its external and internal structure to various members of the Lepidocentridae and is here placed in that family. The chief lepidocentrid characteristics seen in *Lepidechinoides* are: (1) the possession of two columns of ambulacral plates, all primaries, imbricating adorally and under the adradial columns; (2) uniserial pore-pairs; (3) interambulacrum composed of many columns of thin, high plates imbricating adapically and from the center laterally over the ambulacral areas; (4) primordial interambulacral plate in the basi-coronal row; (5) small oculars and low, wide genitals having many pores each; (6) ambulacral plates only on the peristome.

There are eight genera known in the Lepidocentridae, as follows: *Koninckocidaris* Dollo and Buisseret, *Lepidocentrus* Muller, *Tornquistellus* Berg, *Hyattechinus* Jackson, *Pholidechinus* Jackson, *Palaeodiscus* Salter, *Devonocidaris* Thomas, and *Deneechinus* Jackson. At the outset it may be stated that *Lepidechinoides* Olsson, as far as known, differs from all the genera named except *Hyattechinus* in the possession of internal spinose processes, and from all the genera except *Palaeodiscus* in the possession of flabelliform ambulacral plates opposite the transverse adradial sutures.

Lepidechinoides differs from *Hyattechinus* quite markedly, however, in the shape of the test, that of *Hyattechinus* being depressed. The test of *Lepidechinoides*, on the other hand, is high sphaeroidal and was probably nearly circular when viewed from the apex or mouth. Another important difference between the two genera is seen in the ambulacral areas of *Hyattechinus* which are broad and petaloid with relatively high plates ventrally, but narrow with relatively low plates dorsally. *Hyattechinus* also has up to eleven and fourteen columns in an interambulacral area.

From *Palaeodiscus* the genus under discussion varies in its higher test, lesser number of interambulacral columns, and in not possessing the axial stiffening on the inside of the ambulacrum.

Lepidechinoides differs from *Lepidocentrus* in its possession of fan-shaped ambulacral plates and internal spinose processes. The interior of the ventral portion of *Lepidocentrus rhenanus* Beyrich is figured by Jackson[1] but the structures referred to above are not indicated. Another important difference between the two genera, however, is the greater number of ambulacral plates opposite an adradial plate, there being eight in *Lepidocentrus* whereas four is the maximum known in *Lepidechinoides*.

Koninckocidaris differs from *Lepidechinoides* in its higher ambulacral plates, larger number of interambulacral columns, and in possessing primary tubercules on the adambulacral columns. Further, *Koninckocidaris* does not have fan-shaped ambulacral plates internally. *Tornquistellus* is known from isolated interambulacral plates only, which are thin, imbricating and provided with sparsely distributed secondary tubercles only. In this respect it resembles *Lepidechinoides* but the genus is based on too little evidence to refer the specimens under consideration to it.

The Mississippian genus *Pholidechinus* differs from *Lepidechinoides* in having biserial pore-pairs and a larger number of ambulacral columns. It is also unique in possessing delicate flanges on the periphery of the plates. Jackson's genus *Deneechinus* differs from the genus in question in the presence of several small perforate primary tubercles on the interambulacral plates.

From the Upper Devonian (Lime Creek shale) comes the genus *Devonocidaris*[2] described from scattered spines, plates, and lantern débris. Each interambulacral plate bears a large central, perforate primary tubercle. The foramen magnum of the lantern is moderately deep, spines measure up to 11.4 mm. Thomas states that definite evidence of imbrication of the plates is obscure, and therefore the reference of the genus to the Lepidocentridae is doubtful. The presence of large, central primary tubercles, moderately deep foramen magnum, and the presence of "compound ambulacral plates"[3] are sufficient to distinguish this genus from *Lepidechinoides*.

[1]Mem. Bost. Soc. Nat. Hist., vol. 7, pl. 20, fig. 7, 1912.

[2]Iowa Geol. Survey, vol. 29, p. 499, 1924.

[3]Compound ambulacral plates are unknown in Paleozoic echini, being seen first in the Centrechinoida. Thomas is evidently referring to occluded ambulacral plates, and *Devonocidaris* may be related to *Lepidesthes*.

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CONODONTS FROM THE ARKANSAS NOVACULITE, WOODFORD FORMATION, OHIO SHALE AND SUNBURY SHALE[1]

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ABSTRACT

The present paper is based on collections made from five localities; the lower Sunbury shale and the top of the Ohio shale near Columbus, Ohio; the Woodford formation south of Ada and in Ti Valley, Oklahoma, and from the Arkansas novaculite exposed in the Potato Hills, northern Pushmataha County, Oklahoma. Eighteen species were found in these collections, all of which have been described from the Hardin sandstone of Tennessee and the Chattanooga shale of Alabama. Many new forms have been found, especially in the Woodford formation, which will be described in a later paper.

Little work has been done on the conodonts from basal Mississippian rocks in the United States, and less published. These basal formations have almost as many names as there have been sections studied. Probably the best known is the Chattanooga shale, the type locality of which is in southeastern Tennessee. This name is used in Alabama, Kentucky, Virginia, southern Illinois, and the Ozark Mountain region in Missouri, Arkansas and northeastern Oklahoma. Other lower Kinderhook formations are the Hardin sandstone which lies below the Chattanooga shale in Tennessee; the Berea sandstone and Bedford shale in Pennsylvania and New York; the Sunbury shale, Berea sandstone, and Bedford shale in West Virginia, Ohio, Indiana, and Michigan; the Saverton and Grassy Creek shales in northern Missouri; the New Albany shale in Indiana and western Kentucky; the Sweetland Creek shale in western Illinois and Iowa; the upper and middle divisions of the Arkansas novaculite of western Arkansas and eastern Oklahoma; and the Woodford formation of south central Oklahoma. To this list many would add the Cleveland shale of northern Ohio and the Ohio shale of central Ohio.

Ulrich and Bassler[2] have failed to find a single instance of structurally identical conodonts occurring in both Devonian and Mississippian

[1]Published by permission of the Director, Oklahoma Geological Survey.

[2]Ulrich E. O., and Bassler, R. S., A classification of the tooth-like fossils, conodonts, with descriptions of American Devonian and Mississippian species: Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 2, 1926.

rocks. Therefore these fossils furnish the most conclusive paleontologic evidence concerning the stratigraphic position of these black shale formations. Ulrich has long advocated the post-Devonian age of the Chattanooga and Ohio shales and believes that the conodonts establish this contention conclusively. These shales contain a conodont fauna similar to that found in the Sunbury shale which overlies the Berea sandstone in central and southern Ohio. Since the Berea is of unquestioned Mississippian (lower Waverlian) age, the age of formations containing the same fauna must also be classed as Mississippian. Five important papers[1] which have a bearing on this subject have appeared during the last ten years. These describe both Devonian and Mississippian forms. The classification of Ulrich and Bassler is used as a basis for the determination of the forms discussed in this paper, although it is thought that the zoölogical affinity ascribed to the conodonts by those writers is subject to question.

The present paper is based on the already described forms which the writer has collected from five localities, namely: the lower Sunbury shale and the top of the Ohio shale northeast of Columbus, Ohio; the Woodford formation south of Ada and in Ti Valley, southern Pittsburg County, Oklahoma; and from the Arkansas novaculite exposed in the Potato Hills, northern Pushmataha County, Oklahoma. It does not include any of the new forms found at these localities; these will form the subject of a later paper.

In the collections just mentioned (see Plate 20 and Faunal Chart) eighteen forms were found which have been described by Ulrich and Bassler from the Hardin sandstone of Tennessee and by Holmes from the Chattanooga shale of northern Alabama. No forms, either new or described, have been found which may be classed as Devonian. Two species occur in all five of the collections, one in four, and three were found at three locations.

The collection from the Arkansas novaculite in the Potato Hills is most significant in that the material was obtained very near the

[1]Bryant, William L., The Genessee conodonts, Bull. Buffalo Soc. Nat. Sci., vol. 13, no. 2, 1921.

Ulrich, E. O., and Bassler, R. S., op. cit.

Hibbard, R. R., Am. Jour. Sci., 5th ser., vol. 13, pp. 189-208, pls. 1-4, 1927.

Holmes Grace B. A bibliography of the conodonts with descriptions of early Mississippian species: Proc. U. S. Nat. Mus., vol. 72, art. 5, 1928.

Roundy, P. V., The microfauna of the Mississippian formations of San Saba County, Texas: U. S. Geol. Survey, Prof. Paper 146, 1926.

base of the middle division. Ulrich[1] has been quoted to the effect that "the middle and perhaps also the upper division are to be correlated with the Woodford chert in the Arbuckle Mountains and with the Chattanooga shale. He believes, however, that a small part of the middle division is of the same age as the Genessee shale of the Appalachian region." The conodonts which form the basis for these correlations were collected from a minute-pebble conglomerate near the top of the middle division, while those collected by the writer were obtained just above the very dense beds of novaculite which mark the top of the lower division.

The conclusions resulting from the study of these conodonts are as follows:

1. The conodont fauna of the Sunbury shale is matched by that found in the top of the Ohio shale, in so far as available evidence goes. No forms definitely referable to the Devonian, were found in either collection.

2. The entire middle as well as the upper division of the Arkansas novaculite is Mississippian.

3. The large number of species (13) from the Woodford formation seems to establish the correlation of this formation with the Chattanooga shale. This collection was obtained within a few feet of the base of the formation, and this fact places the entire formation in the Mississippian system.

4. Although no new forms are described in this paper, preliminary examination shows that the new species will further substantiate these correlations.

5. No Devonian forms, new or described, were found in any of the collections.

[1]Miser, Hugh D. and Purdue, A. H., Geology of the DeQueen and Caddo Gap quadrangles, Arkansas: U. S. Geol. Survey, Bull. 808, p. 58, 1929.

Also Miser, Hugh D. and Honess, C. W., Age relations of the Carboniferous rocks of the Ouachita Mountains of Oklahoma and Arkansas: Oklahoma Geol. Survey, Bull. 44; p. 10, 1927; and Croneis, Carey, Geology of the Arkansas Paleozoic area; Arkansas Geol. Survey, Bull. 3, p. 108, 1930.

DESCRIPTION OF SPECIES

FAMILY PRIONIODIDAE ULRICH AND BASSLER

GENUS PRIONIODUS ULRICH AND BASSLER, 1926

PRIONIODUS ALATOIDES HOLMES

Plate 20, figure 3

Prioniodus alatoides HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 24, pl. 9, fig. 3.

Bar straight; cusp strong and tapering to point, forming an obtuse angle with the bar; denticles discrete, slanting in same direction as cusp. The specimen figured is much more complete than Holmes' type.

PRIONIODUS CULTURATUS ULRICH AND BASSLER

Plate 20, figure 2

Prioniodus culturatus ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 9, pl. 9, fig. 7.—HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 24, pl. 9, fig. 4.

Bar straight, with discrete, slightly curved and slender denticles rising almost at right angles; cusp long, somewhat curved, at right angles to the bar. The projection is very small as compared with the size of the cusp.

PRIONIODUS REVERSUS ULRICH AND BASSLER

Plate 20, figure 1

Prioniodus reversus ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 10, pl. 9, fig. 4.

Differs from other species in that the denticles and main cusp incline in the opposite direction, that is toward the anterior end; downward extension at right angles to the bar, and about one-third the length of the main cusp; denticles more or less fused in lower half.

GENUS BRYANTODUS ULRICH AND BASSLER, 1926

BRYANTODUS GERMANUS ULRICH AND BASSLER

Plate 20, figure 4

Bryantodus germanus ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 25, pl. 10, fig. 18.

Main cusp one-third of the distance from end of main bar, cusp and denticles slope toward opposite end, and about twice as large as the larger denticles on the end toward which the cusp is inclined more slender than those on the opposite end, bar slightly downcurved, the curvature beginning just below the main cusp.

BRYANTODUS INEQUIALIS HOLMES
Plate 20, figure 5

Bryantodus inequialis HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 27, pl. 10, figs. 1, 2.

Species recognized by the unequal size of the denticles; bar flat and curving; main cusp much broader and about two times as long as the denticles; anterior denticles small and slightly discrete while those on the opposite side of the main cusp are longer, broader, and more or less fused.

BRYANTODUS INCLINATUS HOLMES
Plate 20, figure 6

Bryantodus inclinatus HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 27, pl. 10, fig. 3.

Cusp and main denticles strongly inclined; the denticles on the bar separate, slender and of varying size, but are smaller toward end of the bar, those on downward projection more or less fused; main cusp large and pointed.

BRYANTODUS SUBANGULATUS HOLMES
Plate 20, figure 7

Bryantodus subangulatus HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 28, pl. 10, fig. 6.

Bar strongly arched; denticles unequal on either side of the main cusp, which is only slightly larger than the largest denticles; denticles become smaller towards both ends of bar.

GENUS LONCHODINA ULRICH AND BASSLER, 1926

LONCHODINA IRREGULARIS HOLMES
Plate 20, figure 8

Lonchodina irregularis HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 26, pl. 9, fig. 12.

Bar irregularly curved, carrying more than one large cusp with many smaller, more slender, separated denticles between.

GENUS HINDEODELLA ULRICH AND BASSLER, 1926

HINDEODELLA SUBTILIS ULRICH AND BASSLER
Plate 20, figure 9

Hindeodella subtilis ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 39, pl. 8, figs. 17-19.—HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, pp. 25-26, pl. 9, figs. 10, 11.

Bar long, straight with downcurved anterior end, and covered with numerous separated sharp, slender denticles of two sizes, the larger ones

separated by two smaller teeth; the main cusp long and slender, and together with the denticles, inclined towards the posterior end; in front of the main cusp, and on the downward projection are two or three sets of the two-sized denticles, which however, are slightly curved toward the main cusp in contrast with the straight denticles on the main bar.

EXPLANATION OF PLATE 20

(All figures × 30, except figure 1, × 77).

FIG. 1—*Prioniodus reversus* Ulrich and Bassler. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

2—*Prioniodus culturatus* Ulrich and Bassler. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

3—*Prioniodus alatoides* Holmes. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

4—*Bryantodus germanus* Holmes. Upper Ohio shale, northeast of Columbus, Ohio.

5—*Bryantodus inequialis* Holmes. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

6—*Bryantodus inclinatus* Holmes. Lower-middle Arkansas novaculite, sec. 8, T. 2 N., R. 21 E., Oklahoma.

7—*Bryantodus subangulatus* Holmes. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

8—*Lonchodina irregularis* Holmes. Lower-middle Arkansas novaculite. sec. 8, T. 2 N., R. 21 E., Oklahoma.

9—*Hindeodella subtilis* Ulrich and Bassler. Lower Sunbury shale, northeast of Columbus, Ohio.

10—*Hindeodella longidens* Ulrich and Bassler. Lower-middle Arkansas novaculite, sec. 8, T. 2 N., R. 21 E., Oklahoma.

11—*Hindeodella recta* Ulrich and Bassler. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

12—*Palmatodella delicatula* Ulrich and Bassler. Lower part of Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

13—*Synprioniodina alternata* Ulrich and Bassler. Lower Sunbury shale, northeast of Columbus, Ohio.

14—*Polygnathus pennatulus* Ulrich and Bassler. Lower Sunbury shale, northeast of Columbus, Ohio.

15—*Polygnathus germanus* Ulrich and Bassler. Lower Sunbury shale northeast of Columbus, Ohio.

16—*Palmatolepis perlobata* Ulrich and Bassler. Lower Woodford formation, sec. 3, T. 2 N., R. 6 E., Oklahoma.

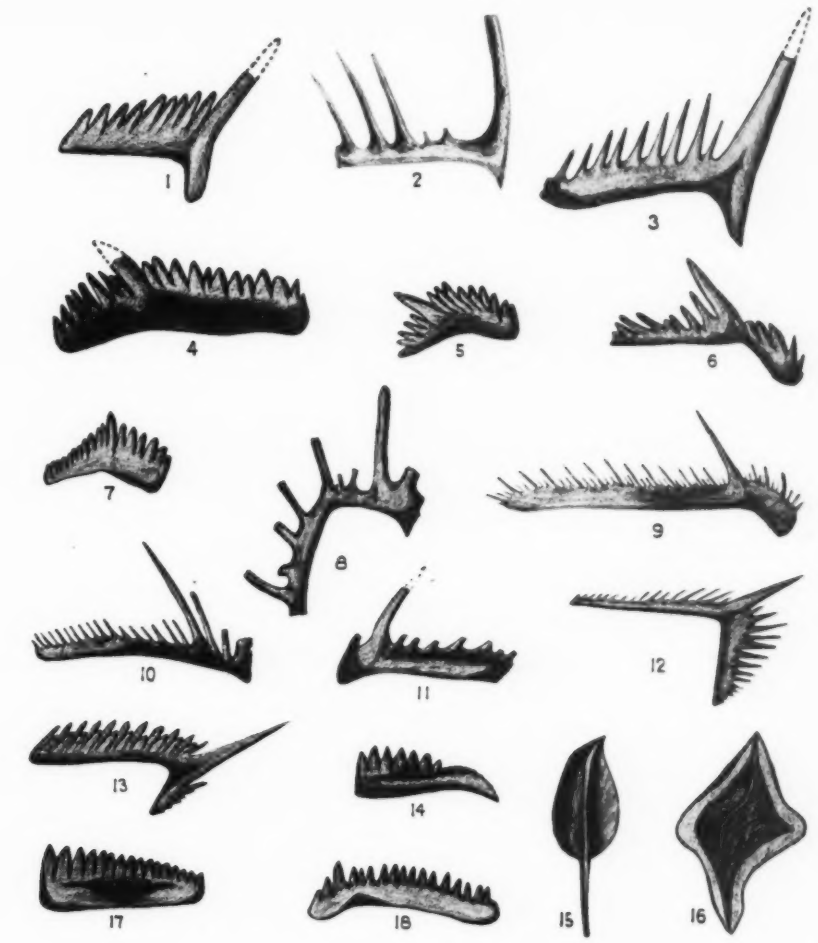
17—*Panderodella truncata* Ulrich and Bassler. Lower Sunbury shale, northeast of Columbus, Ohio.

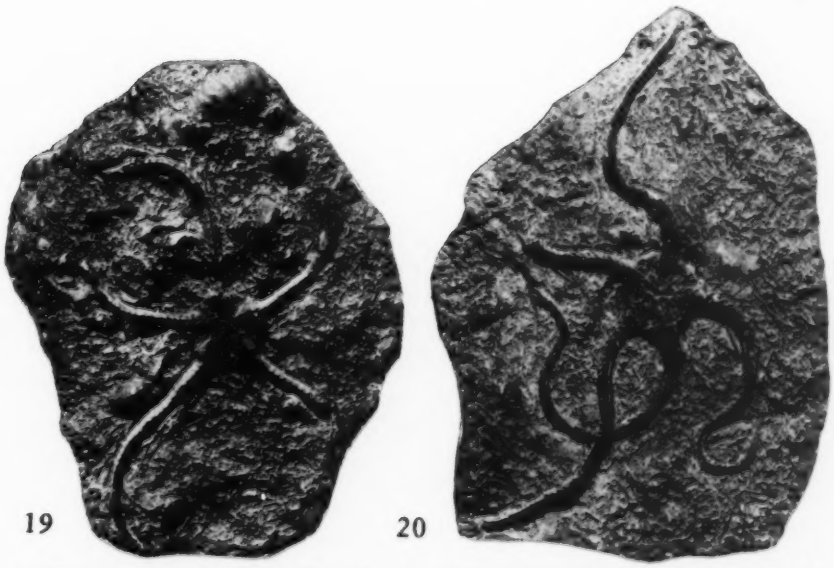
18—*Panderodella subrecta* Holmes. Upper Ohio shale, northeast of Columbus, Ohio.

Figures 19 and 20 accompany paper on A New Lower Cretaceous Ophiuroid, by C. I. Alexander, pages 152-153.

19—Dorsal view of entire specimen of *Ophioglypha graysonensis* Alexander, n. sp. (× 1).

20—Ventral view of another entire specimen. (× 1).





Cooper, Mississippian Conodonts. Alexander, Cretaceous Ophiuroid

UNIV. OF MICH.

HINDEODELLA LONGIDENS ULRICH AND BASSLER
Plate 20, figure 10

Hindeodella longidens ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 40, pl. 8, figs. 14, 15.

Bar slightly curved, with fewer, somewhat stronger denticles, all of equal size, except that they grow slightly smaller near the posterior end; main cusp long and slender with two slender smaller denticles on the anterior side; bar terminated in a short, strong denticle.

HINDEODELLA RECTA UURICH AND BASSLER
Plate 20, figure 11

Hinduodella recta ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 40, pl. 8, fig. 16.

Bar shorter, thicker, and straight with anterior projection small and carrying only one denticle; main cusp relatively short, strong, pointed, and slightly curved; denticles fewer, stronger and short.

GENUS PALMATODELLA ULRICH AND BASSLER, 1926

PALMATODELLA DELICATULA ULRICH AND BASSLER
Plate 20, figure 12

Palmatodella delicatula ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 41, pl. 10, fig. 5 (Text fig. 20, p. 16).—HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 29, pl. 10, fig. 10.

Bar strongly arched, the two parts making a right angle; main cusp broad at base, tapering to a sharp point, and sharply inclined forward; denticles behind cusp and inclined parallel to it are small, separated, and diminish in size toward end of bar, this part of which is very narrow; bar below cusp broader and shorter, carrying a number of long, upright slender denticles near the cusp and which diminish in size downward, giving this part of the specimen the appearance of a serrated palm leaf.

GENUS SYNPRIONIODINA ULRICH AND BASSLER, 1926

SYNPRIONIODINA ALTERNATA ULRICH AND BASSLER
Plate 20, figure 13

Synprioniodina alternata ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 42, text fig. 22, p. 16.—HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 30, pl. 10, figs. 11, 12.

Cusp long, stout, tapering to a sharp point, dividing the bar into two unequal parts, main part straight with fused denticles of two sizes, alternating; downward projection of bar forms acute angle with main

part, carrying five inclined, fused denticles, which diminish in size toward the end.

Family POLYGNATHIDAE Ulrich and Bassler

Genus POLYGNATHUS Ulrich and Bassler, 1926

POLYGNATHUS PENNATULUS Ulrich and Bassler

Plate 20, figure 14

Polygnathus pennatulus Ulrich and Bassler, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 45, pl. 7, fig. 8, pl. 9, figs. 24, 25.—Holmes, *1928*, Proc. U. S. Nat. Mus. vol. 72, art. 5, p. 33, pl. 11, fig. 15.

Median ridge bears denticles throughout its length; carina slightly deflected, and carries several short, stout fused denticles.

POLYGNATHUS GERMANUS Ulrich and Bassler

Plate 20, figure 15

Polygnathus germanus Ulrich and Bassler, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 56, pl. 7, figs. 11, 12.

Numerous specimens referred to this species because of lanceolate outline and lack of tubercular ornamentation.

Genus PALMATOLEPIS Ulrich and Bassler, 1926

PALMATOLEPIS PERLOBATA Ulrich and Bassler

Plate 20, figure 16

Palmatolepis perlobata Ulrich and Bassler, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 49, pl. 7, figs. 19-23.—Holmes, *1928*, U. S. Nat. Mus., vol. 72, art. 5 p. 34, pl. 11, figs. 16-19.

Plate irregularly palmate, crest curved, ridge extending entire length of plate; surface without ornamentation, except for the light-colored border extending around the plate.

Genus PANDERODELLA Ulrich and Bassler, 1926

PANDERODELLA TRUNCATA Ulrich and Bassler

Plate 20, fig. 17

Panderodella truncata Ulrich and Bassler, *1926*, Proc. U. S. Nat. Mus., vol. 68, art. 12, p. 52, pl. 9, figs. 15-17.

Plate subrectangular, tapering toward posterior end, surmounted by a row of broad fused denticles, which grow slightly smaller toward the posterior end.

PANDERODELLA SUBRECTA HOLMES, 1928
Plate 20, figure 18

Panderodella subrecta HOLMES, *1928*, Proc. U. S. Nat. Mus., vol. 72, art. 5, p. 31, pl. 10, fig. 15.

Bar deflected slightly, surmounted by denticles that are short, rather evenly spaced and of approximately the same size.

FAUNAL CHART	*Figure number*	*Hardin Sandstone*[1] *Mt. Pleasant, Tenn.*	*Chattanooga shale*[2] *Huntsville, Ala.*	*Sunbury shale, NE. of Columbus, Ohio*	*Ohio shale, NE. of Columbus, Ohio*	*Woodford shale, S. of Ada, Okla.*	*Woodford shale, Ti Valley, Okla.*	*Arkansas novaculite, T. 2 N., R. 21 E., Oklahoma*
Prioniodus culturatus U. & B.	2	x	x			x		
Prioniodus reversus U. & B.	1	x				x		
Prioniodus alatoides Holmes	3		x			x		
Bryantodus germanus U. & B.	4	x			x	x	x	
Bryantodus inequalis Holmes	5		x			x		
Bryantodus inclinatus Holmes	6		x	x	x	x		x
Bryantodus subangulatus Holmes	7		x			x		
Lonchodina irregularis Holmes	8		x					x
Lonchodina subtilis U. & B.	9	x	x	x	x	x	x	x
Hindeodella longidens U. & B.	10	x						x
Hindeodella recta U. & B.	11	x			x	x		
Palmatodella delicatula U. & B.	12		x			x		
Synprioniodina alternata U. & B.	13		x	x	x	x		
Polygnathus pennatulus U. & B.	14	x	x	x	x	x	x	x
Polygnathus germanus U. & B.	15	x		x?				
Palmatolepis perlobata U. & B.	16	x	x			x		
Panderodella truncata U. & B.	17	x		x				
Panderodella subrecta Holmes	18		x		x			

[1]Ulrich, E. O. and Bassler, R. S., op. cit.

[2]Holmes, Grace B., op. cit.

PALEONTOLOGICAL NOTES

A NEW LOWER CRETACEOUS OPHIUROID

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This new species of ophiuroid or "serpent-star" is based upon two almost complete, beautifully preserved specimens occurring in slabs of limestone from an exposure of the Grayson formation near the town of Everman, southeast of Fort Worth, Texas. One of the specimens displays the dorsal, and the other the ventral surface, and both are so well preserved that they exhibit clearly all details of the structure of both disk and arms.

No less than a dozen other more or less complete specimens and many fragments of the same species are preserved in a few small slabs collected from this locality. The slabs also contain numerous individals of *Goniophorus scotti* Lambert, *Exogyra arietina* Roemer, and fragments of the tests and shells of other echinoids and molluscs.

These highly fossiliferous limestone slabs were collected from a thin ledge at the base of the Grayson, in an exposure on the east bank of Village Creek, about 100 yards south of the bridge which crosses the creek, 2 miles east of Everman on the Everman-Kennedale road.

OPHIOGLYPHA GRAYSONENSIS ALEXANDER, N. SP.

Plate 20, figures 19, 20; Text figure 1

Disk round. Radial shields roughly triangular-ovate in outline, with fairly straight distal borders. Small, circular plate at center of aboral surface. Mouth shields wedge-shaped, distal ends rounded; about twice as long as wide. Diameter of disk 10 mm.; length of arms about 55 mm.; width of arms at disk, about 2.2 mm. Ventral arm plates about as wide as long. Dorsal arm plates nearly twice as wide as long.

This species is somewhat similar to *O. texana* Clark, from the Weno formation, but differs in a number of important characters. Clark describes the ventral arm plates of *O. texana* as wedge-shaped, and his figures show them to be wedge-shaped with a blunt, obtuse angle at the middle of the distal border; the distal border of the ventral arm plates of the present species is straight, or almost so. The proximal border of the ventral arm plates is much narrower than Clark's figures show them to be in *O. texana*, and the oval, ambulacral pores are set obliquely instead of having their greatest diameter paralleling

[1]Clark, W. B., Mesozoic Echinodermata of the United States, U. S. Geol. Survey Bull. 97 (1893), p. 30, figs. 1a, c.

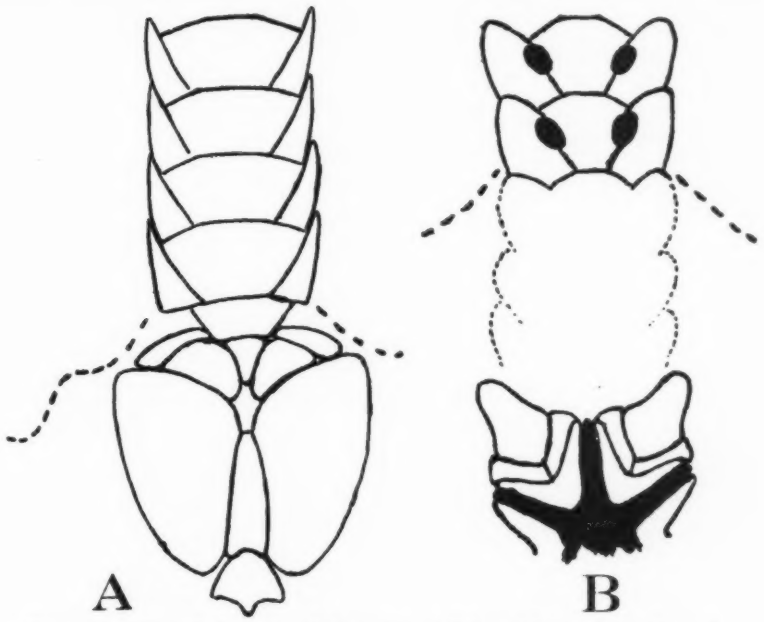

FIG. 1.—A. Dorsal view of radial portion of disk and base of arm (× 10). B, Ventral view of a portion of disk and base of arm (× 10).

the long axes of the arms. Also, the dorsal arm plates of the present species have a much longer and straighter distal border than Clark's figures indicate for *O. texana*.

Since species determination are made largely on the differences in the structure of the arm plates, and since these plates may often be found in the concentrates from clay, shale and marl samples, these fragments should be useful in recognizing the different formations from well samples.

The type specimens are deposited in the geology museum of Texas Christian University.

A NEW SPECIES OF AMPYX[1]

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A new species of Ampyx (Lonchodomas) has been found in the upper part of the Bromide formation of the Simpson group. Only one practically complete specimen has been found which has been made the type, but scores of the cran-

[1]By permission of the Oklahoma Geological Survey.

idia with complete rostral spines occur in the marly limestone at Rock Crossing of Hickory Creek in the Criner Hills, Oklahoma.

TRILOBITA

FAMILY TRINUCLEIDAE BARRANDE

GENUS AMPYX DALMAN

SUBGENUS LONCHODOMAS ANGELIN

AMPYX (LONCHODOMAS) MCGEHEEI DECKER, N. SP.

The type specimen is complete except for the anterior end of the long, slender spine-like rostrum (about 3 mm. broken away) and the edge from the right side of the cephalon. The total length of this specimen is 16 mm. and with the broken anterior part of the rostrum restored it would measure 19 mm.

General Dimensions. Total length 19 mm., rostrum 7 mm., glabella 6 mm., thorax and pygidium 6 mm., thorax 3.5 mm., pygidium 2.5 mm., greatest width 9 mm.

Cephalon. Fixed cheeks and glabella subtriangular, the former almost flat at rear, but sloping steeply on the edge toward the front and sides. Glabella 3.5 mm. wide in the middle, 1.5 mm. at the rear, and anteriorly it is produced into a straight narrow spine-like rostrum which normally is 7 mm. long. A carina is scarcely noticeable except anteriorly where it grades into the posterior end of the rostrum, which is fluted on the under side by an elongate shallow groove. Posteriorly, four elongate, narrow, marginal ridges, two above and two below, extend on the rostrum from the front end of the glabella. Between the ridges shallow elongate grooves occur on the sides and top; these become narrow toward the front and disappear about the middle of the rostrum. All parts of cephalon are smooth and inornate. Free cheeks are wanting

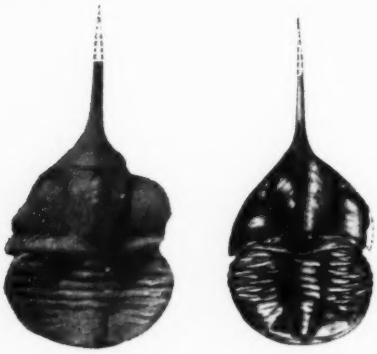

FIG. 1 FIG. 2

FIG. 1.—*Ampyx* (*Lonchodomas*) *mcgeheei*. Dorsal view of type specimen showing restoration of anterior part of rostral spine.

FIG. 2.—Drawing of the type form by McGehee. Both × 2 1/6. Photos by Stovall.

unless they are represented by a thin, flat, narrow plate bordering the outer edge of the fixed cheeks at the base. Posterior occipital furrow marked with edge of cephalon strongly overlapping anterior part of thorax covering the middle part of the first thoracic segment.

Thorax. The thorax consists of six segments with a length of 3.5 mm. and a width of 8.5 mm. With the pygidium it forms almost a half circle, though it is constricted anteriorly to fit under the overlapping cephalon. The width of the axis is 3 mm. and that of each of the pleural lobes is only slightly under that amount. Pleural lobes flat with each segment marked by a plain rounded ridge which is continuous with the one on the axis.

Pygidium. The pygidium is short, broad and smoothly rounded with axis extending to posterior margin. Axis smooth except for four scarcely perceptible furrows. It tapers slowly to end posteriorly in a bluntly rounded end. Two anterior pleural furrows extend from the margin two-thirds of the distance toward the axis and in this specimen the second furrow is more marked on the left than on the right side. The pleural lobes of the thorax and pygidium form flat almost horizontal surfaces, and they look as though they might have been anchylosed so as to move together as a single unit. However, another decapitated specimen shows the pygidium flexed at an angle with the thorax.

Remarks. This new form differs from the species *A. halli* and *A. hastatus* in having a straight rostrum. The rostrum of *A. halli* is arched up in the center, and in *A. hastatus* the front end of the rostrum is bent up and back so as to enclose about three-fourths of a circle.

Horizon and locality. This form occurs with an Upper Black River fauna in which a few more typically Trenton species have appeared. It is found in marly limestone in zone 2 near the top of the Bromide formation of the Simpson group on both sides of the bridge across Hickory Creek at Rock Crossing in Sec. 35, T. 5 S., R. 1 E., 9 miles southwest of Ardmore, Oklahoma, in the Criner Hills.

ORIENTATION OF THE CARAPACES OF PALEOZOIC OSTRACODA

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In the June, 1930, issue (vol. 4, no. 2) of the *Journal of Paleontology*, Dr. J. H. Bonnema published a paper under the above title. The purpose of Bonnema's paper is to describe the orientation of the Paleozoic ostracoda adopted by Ulrich and Bassler and myself and to offer further evidence of the often directly opposite orientation adopted by him. The advantage of his methods of deciding which is the right valve and which the left is said to be established by his comparison of fossils and recent forms. Similar comparisons lead me to contrary conclusions. According to Bonnema the following factors are determinative: (1) The position of the lateral eyes; (2) The position of the sexual organs; (3) The location of the places on the interior of the valves where the adductor is attached; (4) The outline of the carapace; and (5) The manner of closing the valves of the carapace or the difference in size of the valves.

Doubtless all of these means are to be applied in particular cases but 1 and 2 are practically useless in working with the Paleozoic ostracodes because at best we cannot prove they had lateral eyes nor can we form any rational conception of their sexual organs. No. 3 is rendered of doubtful validity because of varying identifications of the muscle scar and No. 5 also is of limited value because the larger overlapping valve may be either the right or the left.

Apparently the most important and certainly the most readily applied and positively determinable of these means are included in No. 4, namely, the outline and contour of the carapace with particular reference to the location of the submarginal swelling that is generally accepted as the broodpouch of the female carapace.

Good and instructive examples of such a pouch are given in the figures of the female of various species of *Beyrichia* published by Ulrich and Bassler in the Maryland Silurian volume. It seems impossible that the greatly amplified end could be the anterior of a freely swimming animal! No well established instance of an equally futile adjustment in living nature comes to mind.

Certainly the instances of "dysteleogy" cited by Bonnema from the works of Abel, Plate and Went and others are not really comparable to conditions found in the Beyrichiidae. Those seem to indicate either overspecialization and underdevelopment of characters that originally were distinctly useful but through subsequent excessive development become definitely harmful; or that two oppositely directed efforts to promote adaptation were operating simultaneously in the same organisms; or they might have resulted through failure in a complicated and experimentally produced condition that may have been of advantage to the individual but unnecessary to the existence of the species. However these cases may be explained, none is known with so unsuitable and harmful a contrivance as would obviously seem to be an anterior position of the broodpouch in the Beyrichiidae and other Paleozoic ostracoda. Suitability in the adaptation of organs is to be taken as a fundamental principle and therefore for granted even when it strains our power of comprehension.

All living ostracodes, so far as they really carry their eggs and young brood around with them, carry them—one might say— independently in the rear portion of the shell, as shown in figure 4 of Bonnema's paper. Without cogent reasons one dare not assume that circumstances were any different in the fossil forms. The idea, that in certain stem forms of the Beyrichiacea in pre-Ordovician times a gradual shifting of the eggs from back to front took place, must be rejected on anatomical grounds. Since no brood pouch or similar thing was at first present anteriorly, but could only be built subsequently as the need arose, the anteriorly deposited eggs would have had to fall in the neighborhood of the whirling anterior appendages, which would be an altogether unsuitable place.

It is easy to understand how old forms which, like *Cytherella abyssorum* Sars, carry their eggs behind, could change to those in which, as in *Primitiopsis planifrons* Jones, the eggs are no longer carried in the posterior part of the shell space itself, but in a brood chamber that is separated from it by a vertical wall. We also understand how in other cases the brood space could be shifted somewhat toward the ventral margin from the rear end. *Primitia* aff. *jonesii* Krause

(1891, taf. 31, fig. 6), *Beyrichia damesi* Krause (1891, pl. 32, fig. 2) and a large number of Zygobolbidae have no definitely separated receptacles for the brood but carry them in undefined swellings of the posterior or post-ventral part of the valves. Of course, it is only the females of these forms that are characterized by the strong swelling of the posterior lobe. It must be assumed that the ovarium lies here also. Thus the broodpouch indicates the rear end of the shell. Using this orientation we reach the same results as in getting an orientation by the help of the median furrow, whose concave side (e. g. in *Beyrichia damesi*) as well as the adjacent tubercle (median lobe) indicates the rear end of the shell according to Ulrich and Bassler.

The further development of the brood containers leads from the forms with merely swollen posterior lobes to those with a hemisphereical oblong or egg-shaped brood pouch, more or less sharply separated from the general shell space and generally located near the post-ventral margin of the valves. Forms like *Kloedenia normalis* Ulrich and Bassler show the transition from brood lobe to brood pouch. Therefore the position of the latter also indicates the rear end of the shell.

Bonnema admits the inexpediency of an anteriorly situated brood pouch and attributes the extinction of the mentioned types to its unfavorable position.

On the other hand it must be pointed out that ostracodes with brood pouches appear already in the Lower Ordovician (Stufe B; F. Schmidt). Consider then that from that date on to the Devonian was a very long time; and that during this long period these ill-equipped types were extremely prolific and particularly rich in species of many genera and several families. Surely such virility could not be repeated under the disadvantageous position of the brood pouch.

For orientation of the ostracode shell, besides the brood pouch and brood lobes, the border (frill) which is converted into a brood space, will serve also. The otherwise flat or outwardly concave border of each valve becomes convex when it is converted into a brood space. Thus there exists a hollow space between the two borders. Such a border space exists in the females of various genera in the Beyrichiacea. Sometimes this is almost symmetrically distributed over the free border as in *Primitia distans* Krause, *Coelochilina* and other Eurychilininae. In such forms orientation of the valves by the position of the brood containers is not always readily achieved. However the species of *Ctenobolbina* in which the marginal loculi for the purpose of caring for the brood are confined to the posterior and post-ventral parts of the border, afford good exceptions to the rule and clearly indicate which end of the shell should be determined as the posterior.

If we orient the shells as Bonnema does, then not only are the brood pouch and the brood lobe but also the convex border that arises independently of them, situated forward. This involves a series of inconveniences. It seems particularly absurd that it is necessary to assume that in forms like *Beyrichia damesii* and many Zygobolbidae the ovarioum was situated forward in the swollen lobe.

Everyone knows that the ostracodes lack a clearly separated head. We may not therefore expect that the anterior end distinguishes itself by a particularly strong sculpture. There was also no reason for the earlier view that

the part of the shell which had the greatest physiognomic expression should be regarded as the cephalic end.

Bonnema found that the shell in the median lobe situated beside the median furrow in *Primitia tolli* Bonnema is thinned down to about half thickness and concluded from this that the location of the eyes was here, and assuming that this must be in the anterior half of the shell he oriented it accordingly. However this median lobe even in *Primitia tolli* appears to be too large for an eye and certainly exceeds in size the eyes of all living ostracodes. But the interpretation of the tubercles as eyes becomes impossible when one considers at the same the median lobe of such forms as *Primitia esthonica* Bonnema, a species from the Kuckers (C_2) and the Backstein limestone (D) of the Baltic Ordovician.

The exceptionally well preserved external casts and exterior impressions of the tubercles in the Backstein limestone show that their surfaces were not otherwise differentiated; and further there is nothing to show whether their entire extent is to be included in the eye or only a small part of the lobe, if any at all. But the concerned tubercles of *Primitia esthonica* cover almost half the shell height and in this respect the species is nearly or quite equalled by a number of related forms. Obviously, on the basis of excess size alone, their interpretation as eyes is highly improbable if not impossible.

The tubercle that is generally admitted as marking the position of the eye in *Leperditia* is in these giants among the ostracodes a mere point. A section through it shows that at its apex, the shell is thinned to much less than half so that a small narrow tube results. The median lobe of *Primitia tolli* therefore is too different from the eye tubercle of *Leperditia* to require its altogether improbable interpretation as an organ of sight. Mere thinning of the shell is not in itself indicative of the location of an eye. If a longitudinal section is made through the richly sculptured shells of *Beyrichia* one sees how the shell thickens and thins again in places where an organ of sight is unthinkable. Further also the *Cytherellina* species show a strongly thinned shell spot that probably has nothing to do with an eye, nor is the spot I mention on the shell of *Steusloffia linnarssoni* (Krause) to be regarded with certainty as the location of the eye. In *Poloniella* (*Kloedenella*) *heiroglyphica* (Krause) Bonnema recognized the more convex end of the shell as the rear end of the female forms. A contrary situation would have been very unsuited for movement through the water, even though much less so than would be the case in those furnished with well developed brood pouches. This species has rightly been included in the genus *Poloniella*, since it has its chief charcateristics, namely, the semicircular incision at the anterior end on the right valve together with the extension of the left valve to fit into it in better development than the genotype, *P. devonica* Gurich. The shell sculpture of the two forms is different, yet *P. hieroglyphica* shows accord with the labyrinthical folding of the other form. Parallelization of the folds of *Poloniella* with those in the Beyrichiacea is already impossible in *P. hieroglyphica* and much less so in the younger Devonian species of the genus. It is therefore unwarranted to refer such other *Kloedenella* species as *K. halli* (Jones) and *K. pennsylvanica* (Jones) or forms like *Dizygopleura stosei* Ulrich and Bassler to *Poloniella*. These species, particularly *Dizygopleura stosei* and *Kloedenella halli* are clearly differentiated from *Poloniella* by their characteristic beyrichiacean lobation, the straight dorsal margins, and the

sharp dorsal angles; they may indeed belong to the Beyrichiacea. *Poloniella* on the contrary, seems more nearly related to *Octonaria* (Family Thlipsuridae of the Cypridacea). Consequently the properly delimited genus *Poloniella* has no relationship with the genera *Beyrichia*, *Ctenobolbina*, *Tetradella* and *Ceratopsis* and cannot serve for their orientation. Many of the younger fossil and living ostracodes, particularly the Cytheridae, are "more developed and higher" anteriorly and posteriorly. Most commonly the shells of Cytheridae have the form of a wedge with a broad vertical edge. Longitudinal ribs which end in the salient point are abundant. But this point is always directed backward and thus does not hinder movement through the water. Orientation by the aid of the longitudinal ribs also agrees with the truth. It seems, therefore, improper to see in their shell form an inconvenience and an analogue to an incorrect orientation of the *Beyrichia* shell.

In regard to the "manner of closing the carapaces" the ostracodes use various means. Among the Paleozoic ostracodes, besides the majority with unequal-valved shells there are also several genera with almost or altogether equal valves, e. g. *Aparchites* and *Macronotella*. Generally among the inequivalve forms most have the right valve the larger and overlapping, as in *Leperditia* and the majority of the Beyrichiacea, but occasionally the left as in *Jonesina* (Kloedenellidae) and *Bythocypris*. Also among the living species no uniformity rules, since the left valve is not always the larger; thus it is the right for example in *Macrocypris*. The overlapping of the valves changes within the same family and apears to have no significance of high systematic rank. It is quite the same whether we orient the Paleozoic ostracodes according to Bonnema's proposal or the very opposite, for in no case can the conclusion be reached that the same valve is always overlapping since a minority of errant forms always remain.

Finally, if Ulrich and Bassler's orientation is to be taken as indicating a certain difference between the Paleozoic and living forms respecting the point of attachment of the adductor muscles, then this circumstance has no weight against the correctness of the above mentioned evidence. It must be kept in mind that in the Beyrichiacea, we are dealing with an extinct opposite ostracode group that is quite strange to present-day forms.

SUMMARY

1. In the shells of Paleozoic ostracodes the brood containers of every sort (brood lobe, brood pouch, marginal space) indicate the rear end.

2. The median furrow lies in the middle of the shell or back of it. It is bent so that the ventral end is directed backward. The median lobe (tubercle) lies behind the furrow.

NOTES ON OSTRACODA

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1. THE FAMILIAL NAMES IN OSTRACODA

Certain erroneous statements as to the proposers and dates of proposal of certain names of families and suborders of ostracodes have become so widespread in the literature that it seems worth while to give a list, which I believe to be correct, for the recent Ostracoda. The groups containing fossil forms exclusively have not suffered in like manner and may be omitted.

Suborder Myodocopa G. O. Sars 1866 (13:99)
  Families Cypridinidae Baird 1850 (4:176)
  Rutidermatidae Brady and Norman 1896 (7:673)
  Sarsiellidae Brady and Norman 1896 (7:675)
  Asteropidae Brady and Norman 1896 (7:628)
Suborder Halocyprinformes Skogsberg 1920 (15:158)
  Family Halocypridae Dana 1853 (8:1281) proposed as a subfamily.
Suborder Cladocopa G. O. Sars 1866 (13:121)
  Family Polycopidae G. O. Sars 1866 (13:121)
Suborder Platycopa G. O. Sars 1866 (13:124)
  Family Cytherellidae G. O. Sars 1866 (13:124)
Suborder Podocopa G. O. Sars 1866 (13:10)
  Families Cypridae Baird 1846 (3:152)
  Bairdiidae G. O. Sars 1887 (14:288)
  Darwinulidae Brady and Norman 1889 (6:121)
  Cytheridae Baird 1850 (4:162)

2. THE OVARIES OF *Cypricercus*

Bonnema (5:113) states that the testes (really testes and vasa deferentia) extend over the entire length of the interlamellar space in the valves of *Strandesia strandesioides*, and asks if this may be true of the ovaries. I have among my material specimens of the closely related *Cypricercus passaicus*. It is doubtful if the distinction between *Cypricercus* and *Strandesia* can be maintained. In the male of this form, also, the reproductive organs have the same arrangement as in *Strandesia*. In Fig. 1a the ovary is the stippled open loop in the posterior part of the valve. Continuous with it is the oviduct, containing unripe eggs next the ovary, and passing out of the interlamellar space and mediad to the abdominal mass at the dorsal border of the shell gland. The latter is the uncolored loop in the center of the valve. The oviduct now runs close to its mate to the genital opening just anterior to the furca. Four ripe eggs may be seen in the distal portion. I give these facts for what they may be worth in the discussion of the orientation of the Beyrichiacea and leperditoids.

3. SHELL STRUCTURE OF *Cythere lutea*

A survey of recent paleontological literature shows considerable variation in the characters assigned to the genus *Cythere*. I am able to point out certain diagnostic characters derived from a study of the type of the genus, *Cythere lutea* O. F. Müller (Recent, North Atlantic coasts).

The shell is of nearly the same shape in the two sexes. The posterior portion of the female shell is slightly broader than in the male. The proportions of the shell in terms of the greatest length are: length 100: height 59: width 51. (Fig. 2b, c).

The surface of the valves shows no prominent sculpture such as ridges or tubercles. There are a considerable number of shallow pits (Fig. 2d), each of which has at its bottom the external end of a rather large pore penetrating the

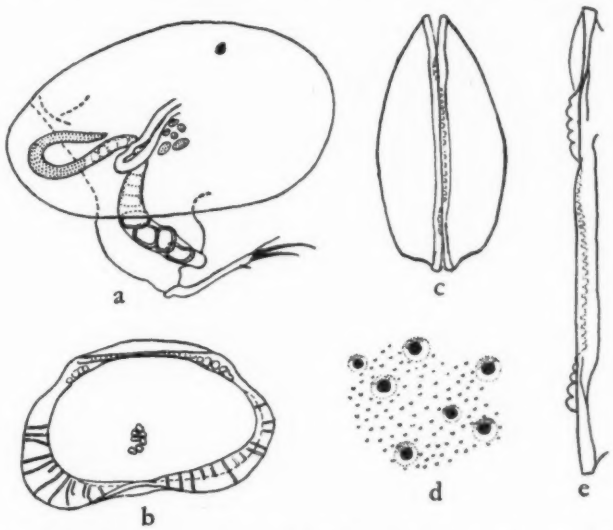

FIG. 1.—*a*, *Cypricercus passaicus*, female, lateral view (× 24). *b-e*, *Cythere lutea*, female. *b*, right valve from within (× 33). *c*, carapace, dorsal view (× 33). *d*, shell sculpture (× 128). *e*, hinge, right valve, dorsal view (× 75).

test. These pores are about 9 to 18 microns in diameter. Each pit is about twice the diameter of the included pore. Between these pits are minute markings, which appear as bright points on the surface of the dry test. They appear to be low papillae.

The pore canals are rather few in number, unbranched and nearly straight.

The hinge bears two teeth on the right valve, one at each end of the hinge line. (Fig. 2e). These teeth are divided into several cusps, so that seen from above the occludent margin is crenulated. Between these teeth is a groove, pitted at the bottom and deepest at its middle. The sockets and crenulated bar of the left valve exactly match the teeth and groove of the right valve.

The discrepancies which will be noted between this description and the classical diagnoses of Brady, Müller and others are due to the fact that their work was based not so much on the type species as on other species now assigned to *Cythereis*, *Leptocythere* or other genera. Some of these genera are very distinct in their shell structure and I hope at another time to be able to consider them. At present *Cythere* appears to be a very small genus comprising, probably, fewer than ten species, recent and fossil.

4. THE AGE OF *Bairdia subdeltoidea*

In an attempt to satisfy myself as to the age of *Bairdia subdeltoidea* I came to the rather surprising conclusion that it is, in fact, a Tertiary species, although very close to several Cretaceous species. The evidence for this statement, at variance with that of Alexander (1, 2), is given below.

Von Münster (11:62-64) lists and describes species of Ostracoda from the "tertiären Sandmergel zu *Astrupp* bei *Osnabrück*" and from other places. Under *Cythere subdeltoidea* at p. 64 he lists the Tertiary localities, Osnabrück, Paris, Bordeaux, and Castell'arquato and as supplementary localities several from the middle stata of the Chalk. Other things being equal we should consider the first named locality as the type locality.

Roemer (12:515) who has the status of first reviser, considers only material from "tertiären Ablagerungen von *Paris, Castellarquato, Palermo, Dax* und dem *Nordwestlichen Deutschland*" and at p. 517 "16. *subdeltoidea* v. Münster" is given as from northwest Germany. Hence, explicitly he selects a type locality and, by inference, from his description of material the type age may be taken as Tertiary. By this elimination we may consider the age and locality to be fixed, but there is interesting contributory evidence which aids greatly in the definition of the species.

Jones and Sherborn (10:17) say: "We have now seen from the Belosepia-bed of Bracklesham (British Museum) a very fine example of the real *B. subdeltoidea*, which we have compared with authentic specimens (from Osnabrück) sent by Count Münster to London many years ago." The Bracklesham specimen is figured on Plate 1, Figs. 15a, b. Further, Jones and Hinde (9,:7) state: "A careful comparison proved the Tertiary species from Bracklesham ('Suppl. Mon. Tert., p. 16') to be the same as Count Münster's species, and there is no dissimilarity at all between these and the Cretaceous specimens here figured." That the Tertiary and Cretaceous forms are identical may be doubted, but it is beside the present point. The essential point is that in each case the authors compared their material to Tertiary material from Osnabrück determined by von Münster as *B. subdeltoidea* and shows that he considered that age and locality as typical.

This evidence has been submitted to Dr. Alexander and he has very kindly written me under date of March 27 that he concurs in my interpretation.

The species from Texas now lacks a valid name and I take pleasure in naming it *Bairdia alexandrina* in compliment to Dr. Charles Ivan Alexander of the Texas Christian University. Descriptions of this form will be found in Alexander (1,:31, pl. 6, fig. 2, 4) and (2,:61, pl. 3, fig. 5), under the name *B. subdeltoidea*. The typical age and locality are the Eagle Ford formation of Texas (Cretaceous) at Station 38 (Alexander, 2,:37).

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NEW NAMES FOR SPECIES OF *BAIRDIA*

BRUCE H. HARLTON

Dr. Charles H. Blake has directed my attention to the fact that *Bairdia nitida*, Harlton, 1928, Jour. Pal. 2, 139 is a homonym of *Bairdia nitida* Jones & Kirkby, 1879 (Quart. Jour. Geol. Soc., vol. 35, 577) from the Carboniferous of England. The new name *Bairdia blakei* Harlton is proposed for *B. nitida* Harlton.

Also *Bairdia marginata*, Harlton, 1929 (Univ. Tex. Bull. 2901, 158) is a homonym of *Bairdia marginata* Bosquet, 1852 (Mém. Cour. Acad. Roy. Belg., vol. 24, 28), from the Tertiary of France. The new name *Bairdia menardvillensis* Harlton is proposed for *B. marginata* Harlton.

SOCIETY RECORDS AND ACTIVITIES

FIFTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The fifth annual meeting of the Society of Economic Paleontologists and Mineralogists was held in San Antonio, Texas, Friday, March 20, 1931. Twenty-five papers were presented. Of these eight dealt with the smaller foraminifera, two with the larger Foraminifera, four with the Mollusca, two with conodonts, three with Ostracoda, one with the Echinoidea, one with Paleozoic spores, one with the Trilobita, and one with the petrographic characters of some Eocene sands. A list of titles is given below.

A business meeting of the Society was held Friday morning, March 20, commencing at 10:30 A. M. The usual reports by the President, Editor, and Secretary-Treasurer were read and approved.

At the close of the business meeting the following officers were elected to serve during 1931-1932:

CHARLES E. DECKER, President
WALTER S. ADKINS, Vice-President
GAYLE SCOTT, Secretary-Treasurer
RAYMOND C. MOORE, Editor

These officers, together with the retiring president, Joseph A. Cushman, constitute the executive committee for the coming year.

The following program was presented:

1. Zonations of Upper Cretaceous on Basis of Ammonites, *by W. S. Adkins*
2. Post-Eocene Section of Chico Martinez Creek, *by Paul D. Goudkoff and Donald D. Hughes*
3. Larger Foraminifera of Claiborne of Texas and Louisiana, *by D. W. Gravell*
4. Larger Tertiary Foraminifera of Venezuela, *by D. W. Gravell*
5. Miocene Foraminifera from Los Sauces Creek, Ventura County, California, *by Joseph A. Cushman and Boris Laiming*
6. A New Species of Lower Cretaceous Ophiuroid, *by C. I. Alexander*
7. Significant Foraminifera of Taylor and Navarro of North-Central Texas, *by John Peter Smith*
8. Petrographic Characters of Some Eocene Sands from Southwest Texas, *by M. S. Metz, M. T. Halbouty, and John T. Lonsdale*
9. Jackson Formation of Texas, *by Alva C. Ellisor*
10. Marine Wilcox, *by Julia Gardner*
11. Taylor Age of San Miguel Formation of Maverick County, Texas, *by L. W. Stephenson*
12. Conodonts for Correlation Purposes, *by Frank H. Gunnell*
13. New Ammonoids of Prolecanitidae and Cyclolobidae from Texas and Their Bearing on Correlation of Pennsylvanian Formations, *by F. B. Plummer and Gayle Scott*
14. Microscopic Fauna from Possible Oligocene Horizon on West Side of San Jacinto Valley, California, *by Fritz E. von Estorff*
15. *Dorothia*, A New Genus of Foraminifera, *by Helen Jeanne Plummer*

16. Correlation Between Later Cenozoic Deposits of California and of Europe, *by Hoyt Rodney Gale*
17. Conodonts from the Basal Mississippian of Missouri, *by E. B. Branson and M. P. Mehl*
18. Spores from Upper Devonian and Lower Mississippian of Missouri, *by R. E. Peck*
19. Ostracods of Snyder Creek, Devonian, of Missouri, *by John Harkey*
20. Conodonts from Grassy Creek Shale of Missouri, *by Paul Kraus*
21. Ostracoda of Sylamore Formation of Missouri, *by Philip S. Morey*
22. Ammonite Zonation in Texas Cretaceous, *by W. S. Adkins*
23. The Genus Cytherelloidea in the Gulf Coast Tertiary, *by Henry V. Howe*
24. A New Species of Ampyx, *by C. E. Decker*
25. New Conodonts from the Woodford Formation of Oklahoma, *by C. L. Cooper*

REPORT OF THE SECRETARY-TREASURER
March 15, 1931

The membership of the Society of Economic Paleontologists and Mineralogists on March 1, 1931, numbered 230 active members and 40 associate members. Dues were collected July 1, 1930. During the past year 21 new active members and 13 associate members have been elected. Applications now pending number 19.

Your secretary has followed the policy of past secretaries and has directed his energies toward maintaining and increasing the revenues of the Society through the sale of back numbers of the *Journal*, obtaining new subscriptions, new members, and advertising for the *Journal of Paleontology*. The total paid subscription list of Vol. IV of the *Journal* amounts to 617. At intervals several hundred circular letters illustrating and describing the *Journal* have been sent out to libraries, laboratories, and paleontologists in this country and abroad. Several hundred letters have also been sent out to prospective advertisers soliciting business. The total advertising amounts to 8 pages yielding $365 of revenue. This does not include advertisements which will expire and be collectable after March 15, 1931. One page, advertising the publications of The American Association of Petroleum Geologists is an exchange for an advertisement of the *Journal of Paleontology* printed in the Bulletin. The one-sixth page advertisement of Max Weg is also an exchange for a similar amount of space in *Der Geologe*.

At the invitation of the members of the Department of Geology of the University of Oklahoma, the Geological Survey of Oklahoma, and geologists and paleontologists at Ardmore and Ada, the fall field meeting of the Society was held October 25 and 26, in the vicinity of these two towns. A complete report of this interesting meeting was published in Volume IV, No. 4 of the *Journal*.

On the Pacific Coast and in the larger cities in Oklahoma, Louisiana and Texas, local sections have continued active, and interesting monthly meetings have been held. It is hoped that these activities will continue, and that additional local sections will continue to be organized.

The printing of the *Journal of Paleontology* during the past year was let to the Mid-West Printing Company of Tulsa, Oklahoma, and Nos. 3 and 4

and Supplement 1 of Volume IV have been printed by that company. Nos. 1 and 2 were printed at Bridgewater, Massachusetts.

Altogether Volume IV and supplement contain 583 pages and 45 plates. These have been printed at a total cost of $4,943.41. The Volume was printed in lots of 1,000 copies. On account of increased circulation the Council has decided to print 1,200 copies of Volume V.

The present financial status of the Society is satisfactory, as shown by the following statement:

FINANCIAL STATEMENT AS OF MARCH 15, 1931

RECEIPTS

Balance from March 1, 1930	$1,780.12	
Donations toward publication, A. A. P. G.	1,000.00	
Subscriptions	2,373.44	
Membership dues	1,064.00	
Advertising	355.00	
Interest on bonds	70.00	
Sale of Penn. R. R. bonds	2,000.00	
J. Brookes Knight—Purchase of Supplement	148.10	
Total Receipts		$8,790.66

DISBURSEMENTS

Secretarial and clerical work	$485.00		
Postage, express, freight	317.63		
Printed forms, stationery, supplies	153.30		
Returned checks, cancelled subs. and bank chgs.	9.00		
Telephone (long distance and telegraph)	7.09		
		$972.02	
Printing of Journal of Paleontology:			
Volume IV, No. 1	915.00		
Volume IV, No. 2	906.60		
Volume IV, No. 3	981.35		
Volume IV, No. 4 and Supplement	2,140.46		
		4,943.41	
Paid on Journal of Sedimentary Petrology	72.75		
Cuts on March No. Journal of Paleontology	21.25		
Plates for March No. including Sep. for authors	180.62		
		274.88	
Total Disbursements			$6,190.31
Balance on hand ($1,500 in savings at 4%)			$2,600.35

ASSETS

Stock of Journals:		
Volume II (528 complete copies)	$3,168.00	
Volume III (297 complete copies)	1,802.00	
Volume IV (365 complete copies)	2,160.00	
		$7,130.00

Bills collectable:		
Membership dues	$ 88.00	
Sales of Journals (Subscription and copy sales)	184.90	
Advertising	575.00	
		847.90
Journal of Paleontology and Sedimentary Petrology for 1931 already paid		274.88
Total assets		$8,252.78
GRAND TOTAL (assets plus cash balance)		$10,853.13

Signed:

GAYLE SCOTT
Secretary-Treasurer

ELIZABETH HARRIS,
Assistant to Secretary-Treasurer

Audited by:
F. B. PLUMMER
C. I. ALEXANDER

Memorial

JAMES PERRIN SMITH
1864-1931

James Perrin Smith, Professor Emeritus of Paleontology at Leland Stanford, Jr., University and honorary member of the Society of Economic Paleontologists and Mineralogists, died suddenly of pneumonia at his home in Palo Alto, California, January 1, 1931.

Dr. Smith was born near Cokesburg, South Carolina, November 27, 1864. He studied in the Preparatory School of Wofford College, Spartanburg, from 1876 to 1879, and in Wofford College from 1880 to 1884, where he received his A. B. degree. From 1884 to 1887 he attended Vanderbilt University, where the M. A. degree was conferred upon him in 1886. He taught in the Nashville, Tennessee, high school from 1886 to 1888 and then joined the Arkansas Geological Survey as assistant chemist and geologist, and worked in Arkansas from 1888 till 1890. In 1890 he went to Göttingen, Germany, to study under Professor von Koenen and Professor Liebisch. From this university he received his Ph. D. degree in 1892. After returning to the United States he accepted an invitation from Dr. J. C. Branner to become Professor of Paleontology and Mineralogy at Leland Stanford University, California, where he remained until his death this year.

Dr. Smith's first noteworthy publication, read before the American Philosophical Society in October, 1896, was on marine fossils from the Coal Measures in Arkansas. It contained 72 pages of text and 9 plates illustrating new fossils. More than half of the species described were ammonoids. The study of these forms which he collected during his first professional position in Arkansas so interested him, that he was drawn into an intensive study of ammonoids that lasted throughout his life and bore rich scientific fruit. In 1897 Dr. Smith published a paper in the Proceedings of the California Academy of Science on *Glyphioceras*, setting forth the results of his researches on the phylogeny of this important genus. His best known paper is a monograph on the Carboniferous ammonoids of America published in 1903. In this all the known species of this group in North America were illustrated and described, a new classification of ammonoids was presented, many new genera established, and new phylogenetic relationships pointed out. This work was followed in 1905 by another monograph on the Triassic cephalopod genera of America. In this work he stands as collaborator with Professor Alpheus Hyatt, whose sudden death left Dr. Smith with most of the work incomplete, and to him went the task of completing the two hundred pages of text and eighty-five plates. In 1913 he revised and rewrote the chapter on Cephalopoda in Eastman's translation of Zittel's Textbook of Paleontology. These monumental works were followed in 1914 by another monograph on the middle Triassic marine invertebrate faunas of North America, which is the most important contribution to date on early Mesozoic fossils. His next publications were short papers

JAMES PERRIN SMITH

on regional faunas and subjects, of which one of the best is on the Permian ammonoids of Timor, in Het Jaarboek van het Mijnwezen in Nederlandische Indie for 1926. The scholarly treatment of the material, the concise descriptions of the species, and the carefully prepared illustrations in his many contributions constitute a lasting testimonial of his high scientific achievements.

In 1925 Dr. Smith was elected to membership in the National Academy of Sciences, and in 1928 he received the Mary Clark Thompson Gold Medal for his researches in geology and paleontology.

Next to his achievements in paleontologic research is his success as a teacher. One of his colleagues at Stanford has said of him "he was first and always a teacher." He was held in highest regard by all his students both in and out of the classroom. When he returned as head of the department at Leland Stanford in 1922, the graduates of the department presented him with ten thousand dollars, a magnanimous tribute of their deep regard for a beloved teacher, adviser, and friend.

F. B. PLUMMER

[1]Personal communication with Solon Shedd, to whom the writer is indebted for data in this memorial.

REVIEWS AND NEW PUBLICATIONS

FRANKE, A., TRENNUNG DER MIKROFOSSILIEN AUS SANDIGEN SCHLÄMMRÜCKSTÄNDEN MIT TETRACHLORKOHLENSTOFF: Zeit. f. Geschiebeforsch., Bd. 6, H. 4, pp. 162-164, 1930.

In addition to brief outlines of several well-known methods of separating microfossils from sandy residues, Franke has described in detail the exceedingly efficacious method employed by the recently deceased Prof. Ozawa, as follows:

"For the Thoulet solution Prof. Ozawa substituted carbon tetrachloride (CCl_4), the specific gravity of which is 1.6. His method is simple and very practicable. and it yields excellent results, and it therefore seems worthy of becoming better known. After separating the coarser ingredients from the dried concentrate by sifting, a small portion of the material to be examined is placed in a small porcelain dish about 7 cm. in diameter and covered well with carbon tetrachloride. A rotating motion of the dish on the tabletop induces the foraminifera to rise and to float on the liquid. A glass tube is furnished with a funnel about 6 cm. in diameter, and into this is laid a filter of bolting silk, a fine sieve, or metal gauze (meshes of about 0.15 to 0.20 mm.). Into this the liquid is quickly poured, in such a way that the sand remains behind in the porcelain dish. As the carbon tetrachloride quickly evaporates, the foraminifera on the filter are ready for examination within a few minutes. Heavier foraminifera that have not flowed into the filter can be extracted with tweezers. Used carbon tetrachloride can again be used. If it is desirable to repeat the process, the material in the porcelain dish must first be dried. With skill this method will isolate all the forams present in the material.

"With material in which the foraminifera are filled with foreign matter or with concentrates composed of mineralized fossil remains, as in the older rocks, such as the Jurassic shales and marls, this method fails. According to Debes, under such conditions the Thoulet solution is also ineffective in isolating the microfossils.

"The advantages of carbon tetrachloride over Thoulet solution or other heavy liquids are quite important, for it is cheap, convenient, and practicable, not poisonous, and it possesses no disagreeble odor."

HELEN JEANNE PLUMMER,
Austin, Texas

W. C. MANSFIELD, of the United States Geological Survey, MIOCENE GASTROPODS OF THE CHOCTAWHATCHEE FORMATION OF FLORIDA, Florida State Geological Survey, Bull. 3. 21 plates.

On paleontological evidence the Choctawhatchee is divided into three zones in ascending order as follows: the *Arca*, *Ecphora* and *Cancellaria*. The last named zone is closely related to the Duplin marl of the Carolinas.

Dr. Mansfield reports 94 genera with 205 species and subspecies of gastropods, of which 94 are of the latter are new. Seven species and subspecies of scaphopods are reported with one subspecies new.

JOSEPH A. CUSHMAN, THE FORAMINIFERA OF THE CHOCTAWHATCHEE FORMATION OF FLORIDA, Florida State Geological Survey, Bull. 4. 12 plates.

On the evidence of foraminifera Dr. Mansfield's lower or *Arca* zone is fairly distinct. The middle and upper zones, Mansfield's *Ecphora* and *Cancellaria* zones respectively, appear to be difficult if not impossible to separate on foraminiferal evidence.

Faunal relationships are noted to the Miocene of adjoining regions in the Gulf Coastal plain, to the Miocene or uppermost Oligocene of Europe and to the Miocene of the Gatun formation of the Panama Canal Zone, the Miocene of Cuba and Santo Domingo and the Miocene and Oligocene of California.

Dr. Cushman reports 54 genera of 108 species and subspecies, of which 13 of the latter are new.

WILLIAM K. GREGORY, of the American Museum of Natural History, A FOSSIL TELEOST FISH OF THE SNAPPER FAMILY (LUTIANIDAE) FROM THE LOWER OLIGOCENE OF FLORIDA, Florida State Geological Survey, Bull. 5. 2 text figures and 4 plates.

Dr. Gregory describes a fossil fish from the Marianna limestone as a new species, viz., *Lutianus avus*. It is believed to be the first record of a fish of this family from the early Tertiary of the Atlantic Coast. The resemblance of the specimen to the living snappers is pronounced.

W. STORRS COLE AND GERALD M. PONTON, THE FORAMINIFERA OF THE MARIANNA LIMESTONE, Florida State Geological Survey, Bull. 5. 7 plates.

The following foraminifera appear to be restricted solely to the Marianna limestone: *Lepidocyclina mantelli* and its variety *papillata*, *Eponides mariannensis* and *Operculinella dia*. Using the small foraminifera, the typical Marianna may be recognized by faunal grouping.

The authors record 56 species and varieties of which 6 are apparently new.

R. RUTSCH, EINIGE INTERESSANTE GASTROPODEN AUS DEM TERTIÄR DER STAATEN FALCÓN UND LARA (VENEZUELA): Jahresversammlung der Schweizerischen Paläontologischen Gesellschaft. *Eclogae geologicae Helvetiae*, Bank 23, No. 2, 1930.

O. SEITZ UND R. RUTSCH, DIE GATTUNG *Amotapus* OLSSON, EINE ECHTE ALTTERTIÄRE *Mya* (*Raetomya*) LINNÉ: Jahresversammlung der Schweizerischen Paläontologischen Gesellschaft. *Eclogae geologicae Helvetiae*, Bank 23, No. 2, 1930.

CLINTON R. STAUFFER, THE DEVONIAN OF CALIFORNIA, University of California Publication, vol. 19, no. 4, pp. 81-118, plates 10-14. An excellent discussion of the Devonian faunas of California, together with the description and illustrations of some interesting species.

HUBERT G. SCHENCK, CEPHALOPODS OF THE GENUS *Aturia* FROM WESTERN NORTH AMERICA: Excellent addition to our knowledge of the genus Aturia containing descriptions of 8 species, illustrated by 13 excellent plates.

AMONG PALEONTOLOGISTS

WALTER S. ADKINS has been elected to a Guggenheim Fellowship that provides opportunity for study abroad. He will leave for Europe in September and plans to spend several months in work on Lower Cretaceous fossils, especially types. This is the first Guggenheim followship award for paleontologic research and it may almost be said the first to a geologist.

JOSEPH A. CUSHMAN, RAYMOND C. MOORE, W. H. TWENHOFEL and T. WAYLAND VAUGHAN attended the annual meeting of the National Research Council in Washington on April 25. Mr. Cushman presented a report for the Committee on Micropaleontology, Mr. Twenhofel a report for the Committee on Sedimentation, and Mr. Vaughan a report on Oceanographic Investigations. Mr. Moore was present as representative on the Council for the American Association of Petroleum Geologists.

JOSIAH BRIDGE has discovered typical crinoidal Osage (Mississippian) limestone in the Llano Region of central Texas. This is far from the area of typical development of the Osage beds and is especially interesting from various standpoints.

FRED M. BULLARD reports that provision has been made for a new Geology Building at the University of Texas. This is a much needed improvement and we hope that in the near future Geology and Paleontology at Texas may be as adequately housed as Chemistry which has a splendid new building.

CAREY G. CRONEIS, of the University of Chicago, has about completed a comprehensive study of fossil holothuroids.

BRUCE H. HARLTON, of the Amerada Petroleum Corporation, recently spent a day in the paleontologic laboratories of the University of Kansas in study of collections.

CHARLES W. HONESS, of the Gypsy Oil Company, has been assisting in preparation of the itinerary for the Fall field trip of the Kansas Geological Society in the Wichita-Arbuckle-Ouachita region of southern Oklahoma and Arkansas.

BENIAMIN F. HOWELL, of Princeton University, will spend the summer in Europe studying outcrops of Cambrian formations. He sailed from New York in May. Coöperation of various European paleontologists which has been arranged promises to make the studies especially valuable. On part of the trip Mr. Howell will be joined by Percy E. Raymond, Professor of Paleontology at Harvard.

G. MARSHALL KAY, of Columbia University, will teach in the field Summer School of Geology that is conducted in Wyoming by the University of Wyoming and Columbia University.

WALTER L. MOREMAN, of Texas Christian University, has completed requirements for the doctorate and will receive his degree at the June convocation of the University of Kansas.

RYCROFT G. MOSS, of the University of Kansas, has been awarded the Long Fellowship in Structural Geology at Cornell University for the academic year 1931-1932. During the summer he will be engaged in geologic mapping in the Permian area of north central Kansas for the State Geological Survey.

NORMAN D. NEWELL, of the University of Kansas, has been elected as Fellow in the Department of Geology at Yale University. Stratigraphic studies in Wyandotte, Johnson and Miami counties, eastern Kansas, which he has recently completed will be extended southward during the summer field season. Mr. Newell is especially interested in stratigraphic problems of the Lansing (middle Pennsylvanian) beds of the northern Mid-Continent.

ELIAS H. SELLARDS, of the University of Texas, has been designated as representative of the Geological Society of America on the National Research Council.

W. H. TWENHOFEL, of the University of Wisconsin, is the next Chairman of the Division of Geology and Geography of the National Research Council. He begins his new work at Washington, July first, and will be on leave from the University of Wisconsin for the year following.

CHARLES E. WEAVER, of the University of Washington, has recently published a monumental work on Mesozoic fossils from South America.

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Journal of Sedimentary Petrology

A Publication of the Society of Economic Paleontologists and Mineralogists
a Division of
The American Association of Petroleum Geologists

» CONTENTS »

Foreword	*Editor*	1
The Measurement of the Shapes of Rock Particles	*Allen C. Tester*	3
The Petrography of Some Bottom Samples from the North Pacific Ocean	*Stanley A. Tyler*	12
The Heavy Minerals of the Franconia and Mazomanie Sandstones, Wisconsin	*Arthur Pentland*	23
Some Petrological and Paleontological Relations in Subsurface Stratigraphy	*O. M. B. Bulman*	37
Insoluble Residues of the Hunton and Viola Limestones of Kansas	*J. W. Ockerman*	43
Alteration of Comanchean Limestones of South Central Texas	*Marcus A. Hanna*	47
The Clay Minerals and their Identity	*Clarence S. Ross and Paul F. Kerr*	55
Editorial: Sedimentary Petrology in Retrospect and Prospect	*Henry B. Milner*	66

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